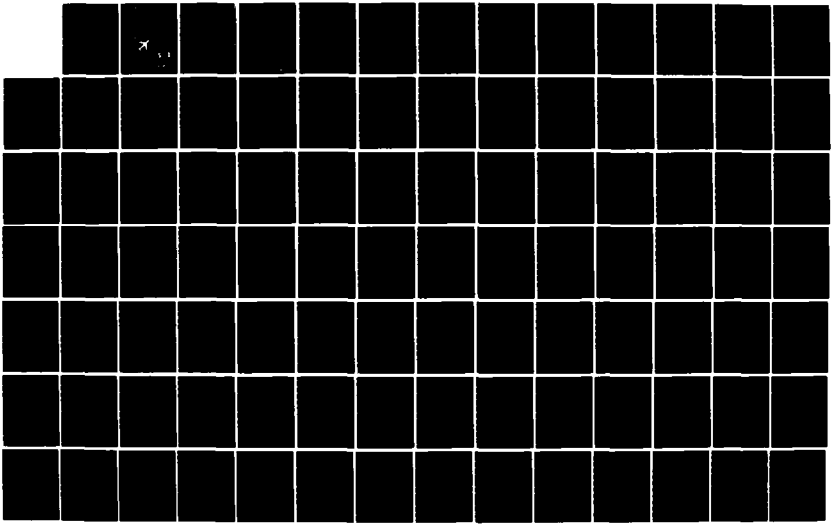
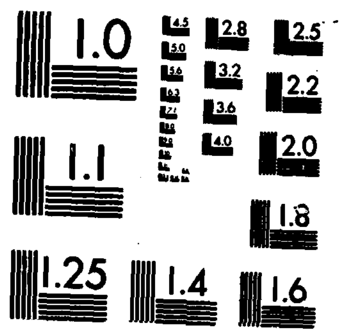
AD-A150 459 HUMAN FACTORS WORKSHOP ON AVIATION (4TH) TRANSCRIPT 1/3
HELD AT ATLANTIC CITY..(U) FEDERAL AVIATION
ADMINISTRATION WASHINGTON DC OFFICE OF AVIAT.. MAY 82
UNCLASSIFIED FAA-ASF-81-9 DOT-TSC-FAA-81-22 F/G 5/5 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

U.S. Department of Transportation
Federal Aviation Administration

Fourth Human Factors Workshop On Aviation

Transcript

May 13-15, 1981

May 1982

Presented at
FAA Technical Center
Atlantic City Airport
Atlantic City, N.J. 08401

AD-A150 459

84 12 17 01F

REPORT NUMBER: FAA-ASF-81-~~8~~9
DOT-TSC-FAA-81-22

DOT/FAA
FOURTH HUMAN FACTORS WORKSHOP
ON AVIATION

Sponsored by the
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Presented at
Atlantic City, New Jersey
May 13-15, 1981

FOREWORD

This document is a verbatim transcript of the proceedings of the Fourth Human Factors Workshop on Aviation held at Atlantic City, New Jersey, on May 13-15, 1981. Another workshop is to be held on July 7-9, 1981 at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

LIST OF ACRONYNMS

AERA - Automated En Route ATC Program

AF - Airways Facilities

AFWAL - Air Force Wright Aeronautical Laboratory

AGL - Above Ground Level

ALPA - Airline Pilots Association

AOPA - Aircraft Owners and Pilots Association

A/P - Autopilot

ARTCC - Air Route Traffic Control Centers

ARTS III - Air Route Traffic Control System

ASR - Surveillance Approach

ASRS - Aviation Safety Reporting System

ATARS - Automatic Traffic Advisory and Resolution Service

ATC - Air Traffic Control

BRITE - Bright Radar Indicator Tower Equipment

BCAS - Beacon Collision Avoidance System

CDTI - Cockpit Display of Traffic Information

CRT - Cathode Ray Tube

DABS - Discrete Address Beacon System

DART - Data Acquisition Retrival Terminal

DOD - Department of Defense

EARTS - En Route Automated Radar Tracking System

ERA - En Route Altitude

ERMSAW - En Route Minimum Safe Altitude Warning

LIST OF ACRONYNMS (CONT.)

ESD - Electronics Systems Division of Air Force Systems Command

ETABS - Electronics Tabular Display Subsystem

FAA - Federal Aviation Administration

FARS - Federal Air Regulation

FMS - Flight Management Systems

FSS - Flight Service Stations

GADO - General Aviation District Office

GSA - General Service Administration

HUD - Headup Display

IAM - Independent Altitude Monitor

ILS - Instrument Landing System

INS - Inertial Navigation System

J/TIDS - Joint Tactical Information Distribution Systems

MLS - Microwave Landing System

MPSG - Maintenance Philosophy Steering Group

MSAW - Minimum Safe Altitude Warning

MSL - Mean Sea Level

NAFEC - National Aviation Facilities Experimental Center

NASA - National Aeronautics and Space Administration

NEXRAD - Next Generation Radar

OMEGA - Navigation System

PASS - Professional Airways Systems Specialists

PATCO - Professional Air Traffic Controllers Organization

LIST OF ACRONYNMS (CONT.)

PMS - Performance Management Systems

PVD - Planned View Display

R&D - Research and Development

RDP - Radar Data Processing

SEM - Systems Effectiveness Model

SOP - Systems Operational Plan

TCA - Terminal Control Area

TIDS - Terminal Information Display System

VFR - Visual Flight Rules

VOR/DMEPRNAV - VHF Omnidirectional Range System/Distance Measuring Equipment Area Navigation

SESSION I

(May 13, 1981)

(Wednesday, May 13, 1981, commencing at 9:30 a.m.)

MR. CARLO YULO: May I have your attention, please.

Ladies and gentlemen, I would like to introduce the Director of the FAA Technical Center, Joseph M. Del Balzo.

MR. DEL BALZO: Thank you very much.

Welcome to Atlantic City and to the Federal Aviation Administration Technical Center. We at the Technical Center take great pride and pleasure in hosting the ATC Human Factors Workshop. If there is anything we can do to make your stay here more rewarding, please let us know.

The workshop you will be attending for the next two and one half days is the fourth in a series. Like those that have gone before, this workshop is intended as a forum in which we can draw upon your experience within the National Airspace System to help us develop a more comprehensive view and better understanding of what you consider the critical aviation related human factors issues. When the results of these workshops are compiled, we will have a much improved base of information to assist us in enhancing our human factors systems engineering programs to correct the underlying causes of the problems you have helped to identify. On Friday, we have arranged for you to visit some of the Technical Center Facilities which are used in our human factors/systems engineering investigations.

The FAA presentations scheduled for this morning are designed to give you our view of the structure and operation of the air traffic control system of the future; both near and long term. It is our hope that these projections will serve as a baseline of systems concepts which can help focus your discussions during the remaining sessions of this workshop. These presentations will highlight system operation rather than the human factors issues involved. During the working sessions to follow, we are asking you to tell us what you feel are the critical human factors issues facing the ATC community.

The rapid growth in technology, automation, and complexity which has taken place within the ATC world has created a major technical challenge to

those of us concerned with the human component of that system. The safety, reliability, and productivity of both current and future ATC activities demand the proper integration of man, machine, and software in which each contributes what it does best toward overall system performance. Designing complex man-machine systems so that they function reliably and safely is a significant technical challenge. It requires a balanced fusion of hardware, software, and human factors systems engineering. The Technical Center has long been active in the study of the contribution of the human element to the success of its systems designs. Recently, Dr. Richard Sulzer completed a major effort to review, analyze, and consolidate the research literature relating to the measurement and evaluation of operator workload. Mr. Lee Paul has conducted an experimental analysis of the display specifications for the Flight Service Automation Program. His comprehensive simulation studies revealed that standard displays could be substituted for the high resolution displays originally called for without degrading operator performance; resulting in a potential savings of up to $10 million to the automation program. Last month, the role which computer based speech synthesis and recognition can play in enhancing the communication links within the National Airspace System was demonstrated, by Dr. Connolly of the Technical Center, to a national meeting of scientists active in the field of computerized speech. Dr. Buckley has made significant progress in the development of a System Effectiveness Measurement (SEM) methodology which will greatly increase the objectivity and precision of the Technical Center's evaluations of the impact of proposed modifications upon traffic control system performance. This work has achieved international recognition and, at the request of Dr. Winter, Director of the Institute for Flight Guidance, German Aerospace Research Establishment, further development of this methodology is being proposed as a joint effort between the Technical Center and the West German Government.

Important as these contributions are, they represent but a part of the greatly expanded effort that will be required to meet the human factors systems engineering challenges posed by the complex automated systems yet to come. It is not easy to develop the staff, data base, and support facilities needed to effectively and systematically design the advance systems demanded by the operational environment of the future. However, the FAA has no choice; it must create this capability. I would like to discuss with you some of the

initiatives which the Technical Center has taken to enhance its human factors expertise and resources to provide the support essential for the successful design of advanced systems. These efforts represent the initial steps in the Technical Center's long-range commitment to acquire or develop the quality as well as the quantity of human factors system engineering resources needed to meet the FAA's responsibility to the public to provide aviation systems which make the best possible use of both man and machine.

At my request, a Human Factors Advisory Team has been established to provide me and my staff with recommendations and guidance on human factors plans, programs, and requirements. This advisory team is composed of six highly qualified and experienced human factors/systems engineers representing the university, aerospace, and military communities. This team has already met several times and has made significant contributions to the effectiveness of the Technical Center's human factors program. Briefly, the members of the team are:

- The team chairman is Dr. Anthony Cacioppo, Chief Scientist, Foreign Technology Division of the United States Air Force,
- Ralph E. Flexman, Professor at the University of Illinois and former Director of its Institute of Aviation,
- Dr. Conrad Kraft, Chief Scientist of Crew Systems and Simulation, at Boeing,
- Dr. Lewis Hanes, Manager of Human Sciences for the Westinghouse Research and Development Center,
- Mr. John Kearns, former Principal Scientist, Crew Systems Development, Wright-Patterson Air Force Base, and
- Dr. Robert Besco, President, Professional Performance Improvement Corporation, Adjunct Associate Professor in the Institute of Aerospace Safety and Management of the University of Southern California, and an active airline pilot.

The Technical Center has also contracted with Wright State University for the services of Dr. Malcolm Ritchie, a former Air Force Pilot, with many years of experience in human factors/systems engineering activities. He has been a pioneer in the development and implementation of programs for the training of

a unique type of engineer -- one skilled in both human factors and systems engineering. Dr. Ritchie has provided valuable assistance in the development of the management approaches and philosophy needed by the Technical Center to achieve the capabilities and scope required in its human factors/systems engineering program.

We have also recruited the services of two senior human factors/systems engineers, Dr. George Long and Dr. Lloyd Hitchcock, as permanent members of the Technical Center Staff. Dr. Hitchcock has been assigned responsibility for the Technical Center's in-house human factors efforts which support on-going system developments. Dr. Long will concentrate on longer range objectives: the development of a human factors/systems engineering program to support advanced systems concepts and the development of the data base and methodologies essential to the successful completion of that task.

Collectively, these two individuals provide the Technical Center with direct, in-house access to almost 60 years of nationally recognized aviation human engineering research and management experience.

We have initiated efforts to establish contractual resources which can be brought to bear upon our problems in a timely fashion. First, we are working toward a long-term contractual agreement with a consortium of universities having the experience, interest, and resources essential for effective human factors/systems engineering analysis and research. With this standing agreement in place, the Technical Center will be able to rapidly marshal the quality and quantity of expertise and resources required to support the definition, development and conduct of its long-term research programs. We also intend to make full use of the opportunities for gaining additional expertise through our Faculty Fellows Program in Aviation Research.

To augment our capability to provide human engineering support for our on-going, in-house systems development programs, we are seeking to establish a competitive contract with a human factors support organization. This arrangement would permit us to write task orders covering specific human factors needs, and to have the work under way within a few weeks. Through this contract, we will have access to the additional talent and resources necessary to meet the human engineering challenges of our in-house system design responsibilities.

Valuable though this contract support may be, there is still a need for additional in-house human factors/system engineering skill. To meet this need, Dr. Ritchie, working with Professor Ezra Krendel of the University of Pennsylvania, has established an advanced educational program to provide masters and doctoral level training to currently employed Technical Center engineers. This training presented by the University of Pennsylvania Systems Engineering Department will include a combination of courses in engineering, system analysis, and human behavior designed to provide a single individual with the mix of data and techniques needed for the effective integration of man and machine into our system designs. We currently have four full-time students participating in this program and look forward toward more.

In addition to building an enhanced base of skilled and experienced personnel, the Technical Center continues to provide the type of constantly evolving complex of simulation facilities which is necessary to support a dynamic program of human factors/systems engineering investigations. The Technical Center's Air Traffic Control Simulation Facility provides the FAA with an unique capability for the assessment of the man-machine problems associated with new ATC concepts, procedures, and equipment based upon the performance of representative controllers, working singly or in teams, within a highly realistic operational environment. This facility can be linked to cockpit simulators, located either within the Technical Center or at remote sites, to give the FAA a highly adaptable and cost-effective capability to simulate the overall experience of operating within the air space environment. The Technical Center's own advanced Concepts Cockpit Facility currently houses two general aviation simulators, can provide a wrap-around projection of the out-the-window visual environment, and has the hardware and software needed to drive any desired combination of advanced digital and traditional analog displays. A computer update program is currently underway which will significantly enhance the flexibility of our display generation and simulation capability and markedly reduce the time and effort required to vary system configurations. I urge you to visit a selection of these facilities during the Technical Center tour which is scheduled for Friday morning.

At this point, I would like to acknowledge the contributions of Mr. Carlo Yulo, Chief of our Systems Simulation and Analysis Division. As one of our senior managers, Carlo not only spearheaded many of these human engineering initiatives but has been largely responsible for the Technical Center's participation in this week's workshop.

I hope that this brief description of what we have been doing in the area of human factors/systems engineering has managed to convey to you the depth and sincerity of the Technical Center's commitment to the adequate and effective consideration of the human element in the system. We recognize that the success of our systems design efforts rests upon our ability to make full and proper use of the unique abilities of both man and machine.

We have accepted this challenge for the future and are determined to meet it successfully.

We need your help. This workshop provides the FAA with an opportunity to gather your insights into the nature of the challenge that faces us. I wish you well in our joint endeavors during the next few days and again pledge the Technical Center's full support toward making your task here both pleasant and productive.

Let me introduce now Jim Bispo, who is the Associate Administrator for Air Traffic and Airway Facilities for FAA.

Jim.

MR. JAMES L. BISPO: I would like to also welcome you to this Fourth Workshop on Human Factors as related to aviation safety. Our goal, as it was at the first three workshops, is to establish a common perspective of human factors problems and to identify the issues -- whose resolution can lead to the greatest improvements in safety; specifically, those which affect the Airway Facilities Technician and the air traffic controller. I think it is important that we not overlook the Airways Facilities Technician even though we are talking about air traffic control. I believe the Airways Facilities Technician is equally as important as the controller when it comes to aviation safety.

First, allow me to briefly mention our earlier workshops. The first workshop was held at TSC last November where we took the initial step to establish a common understanding as to ongoing efforts in the human factors area. Second, we tried to develop a dialogue throughout the international aviation community of human factors problems and issues. Third, we tried to gather information to form the basis of a human factors research agenda for the future. At that workshop, panels representing our government, airline pilots, commercial aircraft manufacturers, and commercial airlines presented

and discussed a broad range of important human factors issues based on their wealth of experience and knowledge in the aviation field. We believe that workshop was successful in achieving its intended purpose.

The second workshop is this series was held in conjunction with the Second Annual FAA/Commuter Airlines Symposium in Arlington, Virginia, this past January. At that one-day session, the emphasis was on human factors considerations in the design of modern-day equipment for the commuter airlines. Three panelists, representing the aircraft manufacturers, gave informative presentations on their companies' design philosophies, the principal human factors criteria which are applied, and some specific examples of problems and recommended solutions.

At the third workshop, we continued the process of defining and discussing the critical human factors issues in aviation and what further should be done about them. We wanted to give particular emphasis to gathering inputs from additional segments of the aviation community not formally represented at the previous workshops.

The third workshop has been organized to address human factors issues in five areas: general aviation, helicopter, air traffic control, airline operations, and metrication.

From the third workshop we received some very specific suggestions to consider in our planning process -- and they will be considered.

As I said -- in this workshop we will talk about human factors vis-a-vis the airway facilities technician and the air traffic controller. I envision human factors as a closed loop process which includes the human, the machine, and the way they fit together to keep the system operating and the loop closed. A constant flow of input and feedback from each to the other must be maintained in order to best serve the entire system process. For this reason, I believe that the necessity for understanding of human factors within our system is paramount to safety in aviation. I strongly believe that the interests of productivity and safety can best be served by designing machines to fit humans rather than relying totally upon humans to fit machines. The degree of safety and efficiency which we maintain is directly commensurate with our ability to do that -- but it is not a one-way street.

In considering human factors in air traffic control, we have seen that improved technology and automation are not, in themselves, sufficient to deter occurrences of human error. We have, therefore, directed our efforts towards developing aids which directly benefit and enhance both the abilities and capabilities of humans. An example is a "listening and memory" course, presently under development, which is designed specifically to aid the human memory and reduce the possibility of instances of human error. Bob Orr from our Air Traffic Service will be talking more about that today in airway facilities, we have considered the role of the technician in the development of new equipment. We have tried to realize the role he will play in maintaining its operation and have considered this role in the equipments' design. Preventive maintenance plays a major role in the continuity of equipment operation. Therefore, technical training -- and the way we do it -- in addition to equipment architecture, is one of the many human factors considerations in the development of new equipment. Jerry Thompson, Director of our Airway Facilities Service, will be talking more about that later.

Your presence here today confirms your interest in the continued safety, reliability, and efficiency of our air traffic system, and your recognition of the critical role of the human element in our environment. I hope you will take this opportunity to freely and openly convey to us your concerns and constructive recommendations. Thank you for joining us here at Atlantic City today for this important conference.

Now, it is my pleasure to introduce to you Sieg Poritzky, who is the Director of the Office of Systems Engineering Management.

MR. SIEG PORITZKY: Thank you, Jim.

Good morning, ladies and gentlemen.

You have been welcomed twice and I add my welcome to those.

I am going to try to lead you through this day, first with presentations by FAA people who will tell you a little something of what they are trying to do and some of the issues as we see them, and then some presentations from NASA and the MITRE Corporation, people who have been working closely in the area we have been talking about, followed by presentations by the user community, and some of the people who represent organizations which, in turn, represent the participants in the system.

I think Jim outlined very properly that this is one of a series of activities in which we are trying to gather the views of the community -- the experts in the community -- and in some ways also, of course, the victims of the systems we provide.

I think it is important to focus for just a moment on the kinds of questions we have in mind. We are looking, as both Joe and Jim said, for informed input. It is not easy to get, we found, in the very specific areas that concern us.

We all know the buzz words and we all use them far too much -- man/machine relationships; man is a poor monitor of automated systems, et cetera, et cetera -- and you have heard them all and we know those.

What we are looking for is the toughest part of all: the innovative ideas that, in fact, will make a difference.

I had the opportunity a year or two ago to talk about the dilemma of air traffic control automation to the Air Traffic Control Association. In that presentation I tried to pose the dilemma, the real one, which has to do a great deal with the questions of inattention, boredom, complacency, and there has been a great dirth of ideas in coping with those problems. We do rather well in what people degradingly call knobology, we do reasonably well on specific system optimization, we do much less well -- not just in aviation, but I think across the industry -- in the areas of optimum interaction between men and machines. That is where we need ideas: very specific ones, very specific recommendations.

One interesting anecdote from that ATCA session. We heard from a very well known expert in Air Traffic Control Automation from the United Kingdom, and he, in effect, said "Forget it. You will not provide a genuinely automated decision-making system for air traffic control; the human being must always be involved, and he is the optimum operator of that kind of a system."

He may be right. However, we have seen in the work we have done in attempting to automate the control process and the decision-making process that in order to do the job efficiently and in a fuel-efficient manner, there are simply too many variables for a human being to cope with in the moment to moment decision-making process, and we think there must be automation in the system.

That is an interesting dilemma; and I hope as the days proceed in this particular seminar of the several that we have talked about, that you will give us the ideas and the innovations which we can then tackle.

Now, as I said, we will this morning have a series of presentations to give you a feeling for where we are, what we are currently doing in the areas that impact the questions for this seminar.

I would like to begin that with a presentation by Neal Blake on Automation of the Future System and Transition Considerations.

This presentation, I believe, will give you a good feel for the way we see the system evolving and the kinds of efforts we are now undertaking that will perhaps serve as a base line for the discussions.

Neal Blake, who I suspect most of you know, joined the FAA in 1962 as a member of the National Airspace System Design Team. He has progressed through positions of increasing responsibility in ATC system design and automation, research and development, to his present position as Deputy Associate Administrator for Engineering and Development.

As I said, his paper this morning will highlight FAA's present plans for the application of automation technology to the future ATC system; and he will, of course, focus as much as he can on the interactions between those systems and the people who operate them.

Neal.

MR. NEAL A. BLAKE: Thank You, Sieg, and good morning.

Over the last 25 years, the air traffic control system has evolved from a "manual" control system based primarily on procedural separation techniques to an automation-aided system where many of the routine tasks have been taken over by computers, and radar control procedures form the basis for aircraft separation throughout most of the nation's airspace.

During the late 1960's and early 1970's, computers were installed in the domestic centers and the top terminal facilities. A current program will result in installation of a lower capability automated system at a number of additional radar terminals. Our current major system development programs will result in automation of some of the decision-making functions associated with aircraft separation assurance and metering, sequencing and spacing of

aircraft during the 1980's. An improved landing system and a new surveillance system with integral ground-air-ground data link are expected to enter the system during this same time period.

As we look forward to the next 25 years, we see a number of issues that must be faced and decisions that must be made before the next set of system improvements can be implemented. Some of the fundamental issues include:

- o How far toward a fully automatic ATC system can we, and should we proceed?
- o What is the evolving role of the controller as the level of automation increases?
- o Should responsibility for a larger part of the aircraft separation assurance function be delegated to the pilot?

FAA has recently conducted with the user community a New Engineering and Development Initiatives activity which examined Policy and Technology Choices for the future system. The user inputs resulting from this activity are providing guidance to us in the planning and conduct of programs to attain higher levels of automation in the ATC process. Although definition of the future automated functions is still in a fairly early stage and no clear picture exists, I would like to look into the still cloudy crystal ball with you and identify our best thinking on what the system of the future might look like. I will summarize for you the anticipated evolution of ATC that will take us from today's system to a highly automated system.

The FAA's ATC system is a large complex of men and machines. Control of en route air traffic is provided from 25 Air Route Traffic Control Centers, including 20 automated domestic centers, and 3 automated and 2 manual offshore centers. These systems interface with 182 automated and 16 manual terminal radar approach control facilities and 447 FAA operated control towers. They also interface with 3 automated and 316 manual flight service stations (FSS). Future plans call for consolidating FSS operations at 61 automated facilities.

A portion of the control room in one of the centers is shown here. Each center is organized into a number of high and low altitude control sectors where radar and procedural controllers manage the air traffic within defined airspace regions.

The equipment system making up the automation system in the centers includes the 9020 computers and display channel equipment which provide the automated functions and generate the information on the controller displays. In addition to the primary data channel shown at the top of the viewgraph, there are two backup channels currently implemented in the centers which provide a reduced capability radar display system to be used during periods of computer outage. We are in the process of converting from use of a broad-band channel, shown at the bottom, which presents a scan-converted television image of the radar data, to a much improved direct access radar channel, shown at the center, that displays aircraft and weather information to the controller using data from the digital channel normally supplying the computer. This latter type of display more closely approaches the capability provided by the primary channel. Future enhancements to this system will permit achievement of a backup system capability that is nearly equivalent to the primary channel. It is our intention to discontinue use of the broad-band channel after the direct access radar channel is accepted for operational use.

The 9020 computer complex at one of our centers is shown here. This equipment represents 1962 vintage technology and is physically large. Current state-of-the-art technology will allow development of a more capable computer system approximately one-third this size.

A typical en route sector suite contains radar, procedural and assistant controller positions. I will discuss later the development programs under way that are expected to replace the flight strip printers and flight strip storage bays with electronic displays of tabular flight strip data.

Improvement of the Air Traffic Control System is evolutionary, not revolutionary. Future system improvements are continually under development. In the past, we have had the computer capacity to implement these new functions as they were developed. Implementation of future functions however, will be contingent upon software improvement programs that permit "buy-back" of capability. This viewgraph summarizes the functions in our evolutionary automation ladder.

Today, the primary functions performed by the en route computer systems are radar and flight data processing which provide an all digital display of aircraft track and associated information on controller radar displays and print flight progress strips at control positions.

The next functions, conflict alert and en route minimum safe altitude warning (ERMSAW), aid the controller in detecting situations where safe separation with terrain or other air traffic may be lost. The en route computers also support the controller with a number of additional functions including intersector and interfacility coordination, handoff of radar identification between controllers, and generation of geographic maps and outlines of severe weather storm areas.

Functions currently in the development process that are candidates for near-term implementation, subject to computer capacity availability, include the following:

- o En route metering advisories to assist the controller in achieving desired aircraft flow rates in high density terminal areas. These form the first step of an integrated flow management system.
- o Extension of the conflict alert function to warn the controller when controlled aircraft are predicted to come too close to uncotrolled aircraft operating in the same airspace.
- o Addition of conflict resolution advisories to present to the controller the range of control actions that would result in safer resolution of the conflict situation.
- o Replacement of printed flight strips with electronic tabular displays of flight data and automation of some planning activities.
- o Implementation of interfaces with the new discrete address beacon system (DABS) and the Center Weather Service Unit.

Implementation of additional major new automation functions, which are associated with automated decision-making, will not be possible until the new higher capacity, more reliable en route computer system is operational. Development programs in this area are being carried on in parallel with a program to replace the en route computers and will produce the system improvements needed in the post computer replacement time period. Some of the functions in this area include:

- o Use of the Discrete Address Beacon System data link.
- o Automation of a nationwide traffic flow management service comprised of national flow control, en route metering and terminal metering and

spacing functions -- all aimed at reducing airborne delays.

o Automation of en route clearance generation to reduce planning and control workload in the centers.

I would like to summarize briefly some of the more significant improvements that have recently been added or are planned for addition to the system to support the controller.

Conflict Alert warns the controller of potential separation minima violations two minutes in advance. Altitude clearances are used when manually inserted by the controller. It is now operational above 12,500 feet at all en route centers and to the ground in many of the low altitude sectors. It can be used with primary radar targets when the controller manually inserts aircraft altitude information. In the terminal area, implementation is nearing completion at all ARTS III facilities. Controller reaction to conflict alert have been positive despite occasional complaints about false alarms. We feel that conflict alert is a contributor to increased safety of flight.

The Conflict Resolution Advisories function is designed to provide the en route radar controller with a display of possible alternatives for the resolution of conflicts identified by the conflict alert function. The prime objective of the conflict resolution function is to reduce instances of system error, by reducing decision-making time in complex encounter situations. The conflict resolution function displays the range of alternatives for the resolution maneuver for the controller, who will consider factors such as desired traffic flow, severe weather, communication failures or the presence of uncontrolled VFR aircraft, that are beyond the capabilities of the current levels of automation.

In addition to Conflict Resolution, FAA is developing two other automated systems, intended as a backup to the primary air traffic control system. These are the Automatic Traffic Advisory and Resolution Service (ATARS) and the Beacon Collision Avoidance System (BCAS). ATARS is a ground-based automation function that is performed in the Discrete Address Beacon System (DABS) computer located at the radar site. BCAS is an airborne system that can protect equipped aircraft against other aircraft equipped with at least Mode C encoding transponders, both within and outside ground surveillance coverage.

Minimum Safe Altitude Warning or MSAW, is another automation feature that assists the controller in maintaining flight safety. Here the computer predicts that an aircraft is going to be below a predetermined safe altitude in the next several minutes. The flashing "LOW ALT" shown on this viewgraph warns the controller that a control action may be required.

The en route metering function organizes airport arrival traffic in the en route airspace by metering flights to their destination airports. Flights are scheduled for delivery to metering points for an airport at a rate that matches the acceptance rate for the airport.

The metering function determines a metering fix arrival time for each aircraft. A list of these times will be displayed to the controller for the arrival aircraft.

In order for the metered flights to meet these times, delay absorption strategies are generated to absorb any required delay. Flights progress is monitored along the approach routes to determine the necessity for and amount of delay and, where appropriate, the appropriate delay absorption strategy, such as speed reduction, descent profile adjustment or intermediate fix holding is developed. These advisories are displayed to the en route controller who is controlling the flight.

Since the inception of the air traffic control system, the method of posting flight data information to the air traffic controller has been the paper flight strip. Before the introduction of the present NAS Stage A system, flight data information was entered and updated manually by pencil on the flight strip. The present system uses electro-mechanical flight strip printers which, under computer control, print initial and updated flight data on paper strips at the sectors which will handle the flight. This system required mounting or "stuffing" of the strips into the flight strip holders by hand, placing the holders in the desired position in the flight strip bay, updating the flight data by pencil, and entering updated information into the computer by means of a manually operated keyboard device. This is a cumbersome operation which consumes much of the "D" and "A" controller's time.

The Electronic Tabular Display Subsystem (ETABS) program utilizes electronic displays to replace the flight strip printers and paper flight progress strips now in use at all Air Route Traffic Control Centers (ARTCCs).

Through the use of electronic displays, processors, and touch entry devices, ETABS will automatically provide non-radar flight and control data to the controller.

The introduction of ETABS forms an integral part of the controller suite evolution.

The Discrete Address Beacon System (DABS) will have a significant impact on the controller of the future. It will provide him with more accurate and consistent surveillance information. It will provide a data link between the ground and the aircraft that opens up a variety of possibilities.

I will now turn to a discussion of the longer term automation evolution that will result from FAA's Advanced Systems Engineering activities. This viewgraph depicts the various elements of the Advanced Systems Engineering program and their interrelationships. In keeping with the topic of my talk and the theme of this workshop, I will limit my comments to the most relevant elements: Automated En Route ATC, Integrated Flow Management, Weather Detection and Dissemination (not shown), and Data Link Applications.

Of all of FAA's automation activities, the Automated En Route ATC program (AERA) is likely to have the most significant impact on the controller of the future. AERA will automate most routine ATC functions that are currently performed by the controller. Since AERA will build on and incorporate the existing and near-term automation functions, it can be viewed as a logical next step in ATC evolution.

AERA will automatically perform most en route planning and control processes under the active management of controllers. This system will provide better accommodation of flexible, fuel efficient profiles, increase ATC system productivity, remove many of the causes of system errors, increase ATC service availability, and reduce the potential for pilot error.

AERA will be a set of automated functions, embedded within each en route facility, that will automatically plan conflict-free, fuel efficient profiles for aircraft. It will recognize aircraft conflicts 10 to 20 minutes in advance of their occurrence on the basis of current position and cleared route data, and environment conflicts including predicted penetration of restricted airspace and severe weather areas. It will produce clearances to

resolve these problems. AERA will generate routine clearances using fuel efficient profiles and direct routes, and will present these clearances to the controller. It can also deliver these messages via data link to the pilot. AERA will monitor aircraft progress to assure separation. AERA will protect against system failure by providing a coast capability with backup clearances and will be compatible with the backup systems such as DABS/ATARS and BCAS.

The AERA operational concept assumes that ground-based computers will automatically perform most of the routine ATC planning and control functions under the active management of air traffic control specialists. For IFR en route aircraft these functions will automatically produce a plan of clearances to be issued, either automatically or manually, at appropriate times. The clearance plan, if followed, will ensure that all controlled flights will remain conflict-free, fuel-efficient, and when appropriate, metered.

Aircraft equipped with a DABS data link, AERA navigation equipment, and a flight management computer will be able to take full advantage of the capabilities of the AERA system and will be able to file for and in most cases, receive precise. direct route, fuel optimal flight profiles.

In AERA, the volume of airspace within which the computer can control flight movements is known as its "control region." To avoid discontinuities in the planning and control process, each AERA system begins its planning process before an aircraft enters the control region. It is anticipated that AERA control sectors can be staffed by one or two controllers and that the airspace controlled could be several times the size of current day sectors.

The productivity increases sought in AERA imply an increased traffic load for each controller, so the impact of a system failure on smooth traffic flow and on safety will be much more severe than in the current system. Thus, reliability of both hardware and software will be critical; automated backup capabilities will be needed; and human factors considerations pertaining to these backup capabilities will be important.

Our status on this program is that we have formulated a detailed AERA system operational concept; and we are in the process of developing a detailed functional description of this system. In addition, a real-time AERA testbed capable of examining the role of the controller in an automated environment,

as well as demonstrating concept feasibility, is being developed. A first demonstration of AERA's ability to plan fuel efficient flight profiles was completed last December.

Integrated Flow Management is a requirements definition, concept development, and integration activity. The integrated flow management concept must integrate the functions of national flow management, en route metering, terminal flow and airport operations. This concept will use automation tools to permit the best possible integration of a variety of services and capabilities to provide fuel efficient flight with minimum delays and maximum accommodation of pilot preferences.

In the terminal area, the automation system will support terminal planning and configuration management. It will provide vortex protection and will have the ability to provide conflict-free paths which recognize limitations imposed by weather and wind shear; and it will make use of Microwave Landing System (MLS) procedures and runway occupancy monitoring and control systems. An optimum metering, sequencing and spacing system will ensure minimum time deviation over the threshold. We will be looking at how to best integrate these capabilities into the system and to establish the impact on ATC automation planning.

The overall objective of the Aviation Weather Program is to provide timely weather information to all users of the Nation's Airspace System, to significantly improve the capability for detection of hazardous weather phenomena, and to provide rapid access to the national aviation weather data base by all users. Two areas of particular interest are the development of a new generation of weather radar (called NEXRAD). The second is the development of Automated Weather Observation Systems. This involves the development of new weather sensors and the capability to process sensor outputs into a complete weather observation for voice and digital transmission.

Improvement in severe weather warnings involves the development of a new generation of weather radar using doppler technology to provide radial wind velocity and velocity spectrum width in addition to reflectivity data. Detection of hazardous weather phenomena is expected to be greatly improved through the application of doppler radar technology. A joint program was established within the Department of Commerce to develop and implement the Next Generation Radar (NEXRAD). The FAA is providing both manpower and funding resources in the NEXRAD Joint System Program Office and expects this new

radar system will satisfy its requirements for the detection of hazardous weather in the en route environment. It should be noted, however, that due to siting requirements, scan rates and display update rates, the detection and display of hazardous weather phenomena in major terminals may require a separate terminal weather radar.

This viewgraph depicts one of the possible displays of severe weather phenomena which shows the type of contour and storm movement information that will be made possible by NEXRAD.

A program to examine the use of Cockpit Displays of Traffic Information (CDTI) deserves special mention. While the technology to provide traffic information in the cockpit exists, the pilot's ability to use this information and the impact this will have on the ATC system is not fully known.

Our objective is to evaluate the use of Cockpit Displays of Traffic Information for both passive monitoring and active spacing tasks so that the advantages and disadvantages of such use can be measured in terms of system safety, capacity, and efficiency in operationally realistic environments. We want to evaluate the impact of CDTI on the pilot and on the controller as well as the on traffic flow stability. Other factors to be evaluated include pilot performance in dynamic merging and spacing, display content and format, and pilot/controller workload changes. This work is being done jointly by the FAA and NASA and is addressing general aviation and air carrier use of such displays.

The advanced system engineering functions that I have discussed have two common ties. Nearly all of them require an advanced ATC computer system and data link services. Some of the data link services which are being evaluated are shown here. These have been grouped into several time periods with the near term functions associated with the inner ellipses. The services include:

1. Transmission of traffic and collision resolution advisories associated with ATARS and BCAS.

2. Candidate services for the next time period include: MSAW Advisories, Enhanced Terminal Information Services, En Route Weather, Takeoff Clearance Confirmation, and Altitude Assignment Confirmation.

3. Later services being examined include: Airborne Flight Plan Filing, Hazardous Precipitation Contours and Phenomena Identification Information, Metering and Spacing Clearances, ATC Instructions, Downlinking of Airborne Sensed Weather Data, Clearance Delivery, and Enhanced En Route Weather Information.

4. Post-1990 services may include Cockpit Displays of Traffic Information and Automated En Route ATC Clearances.

5. We believe that the ATC automation program I have discussed will provide a number of significant benefits to both users and operators of the National Airspace System. Some of these are:

- System operation and maintenance costs will be reduced.
- User requested flight profiles will be accommodated to provide, among other things, fuel efficient flight paths.
- Utilization of airspace and runways will be optimized.
- Display of traffic and weather information will be improved.
- Conflict free flight clearances will be generated automatically.
- Air-ground and ground-air communications will be improved.

Clearly, achievement of these benefits is dependent on the establishment of the appropriate distribution of functions between air and ground systems and personnel and provision of the optimum man-machine interfaces.

The benefits of increased automation do not come free or easily. New, more powerful computers with hardware and software designed for growth and evolution will be required. New computers will be required to support continued growth in traffic and will provide the foundation for the automation functions that I have described.

FAA is embarking on an extensive program to replace first its en route computers and later its terminal systems to provide for growth in traffic and further automation of the ATC process. The replacement is also needed as the cost of maintaining hardware and software systems based on 1960's technology is projected to increase significantly in the future.

FAA expects to award multiple concept development contracts to industry in late 1982 or early 1983 to begin the design of a new en route computer complex. Several phases of design, development and testing are planned with implementation scheduled for the late 1980's. The next generation of the controller suite for the en route system will be designed and developed as part of this computer procurement.

The replacement of computer and display equipment in a system that must support continuous operation without degradation in service efficiency or safety, presents us with a difficult transition problem.

Human factors concerns will be a major factor in the transition planning. Substantial efforts will be made to minimize the impact of the transition on controllers and pilots.

First, the new system will fit into the existing communications, surveillance, and navigation environment. Second, the new system, when first installed, will look functionally identical to the old system as seen by the controller. New functions that exist in the initial replacement system will be activated gradually once transition to the new system has occurred. Third, the old system will be available as a backup for at least 90 days after the new system is placed in operation.

These transition requirements go hand in hand and will go a long way toward making the transition a smooth one for the controllers and pilots. Finally, the transition of the displays will follow the computer transition. There are two important human factors reasons for this. First, it will be much easier for the controller to adjust to a new computer system without the added problems of learning to cope with a new display. Second, this transition approach permits a logical evolution of the display systems to match the requirements of the more automated ATC system of the future.

One possible evolution of the sector suite is shown by the next several viewgraphs.

The current sector suite is shown here with the three control positions identified. The automation related equipment affected by the evolution include: the PVD, computer readout devices, data entry and select panels and the flight strip printer.

The first major step in the evolution would be replacement of the flight strip bays at the "D" position with electronic tabular displays. A small display, shown in the console shelf, would provide a fail safe capability for major system failure protection. This display also provides a touch entry capability for data. Note that the "A" position retains the flight strip printer and some strip storage bays to provide a system backup capability during transition.

The next step provides several new displays. The concept shown here has added a weather display and a new PVD to the sector suite and removed the flight strip printer and strip storage bays. This configuration is capable of supporting the advanced en route automation functions. Note that the present PVD is retained for backup to protect against system failures during this phase of the transition.

In the next step, the functions performed by the overhead equipment in the previous viewgraph has been integrated into the consoles shown here. The present PVD console has been removed and a projection type map and auxiliary data display has taken its place. A mock-up of this concept of the future display system is available at the Technical Center and represents one possible future configuration. Other configurations are being defined and will be evaluated as part of our ongoing human factors program.

Understanding the human element in ATC is an important aspect in our advanced automation programs. In conducting our current efforts we are not starting from "scratch," but building on and improving the already high performance of the current system. The focus of our current efforts is not on "knobology" or the location of displays and controls best suited to the physiology of the human being, although this is certainly an important area. Rather, it rests on areas such as the following:

1. The causes and types of human error and the impact of these errors on the safety, performance and productivity of air traffic control system operations;

2. The definition of automation approaches that assume the continued existence of human as well as machine error and strive to avoid both the occurrence and the consequence of such error;

3. Assessment of the proper distribution of air traffic and aircraft control monitoring functions between automation systems and the controller and pilot;

4. Determination of the appropriate interfaces between the man and the machine at each step up the ladder leading to higher levels of automation; and

5. Determination of adequate automated, semi-automated and manual system backup capabilities to permit safe continuation of system operations under a variety of conditions of human and machine system failure.

Now, let me briefly touch on some of the human factor activities being conducted that support the ATC automation program.

Human factor considerations form an important part of the development of new electronic data displays, such as ETABS and the terminal equivalent, TIDS. These considerations span the range of degree of automation of the flow planning process to the optimization of data entry techniques and hardware. Touch entry and menu board selection are of particular interest.

As a part of our program for the future automation system, we have under development a set of controller suite mock-ups, mentioned earlier, which will show several stages in the evolution from the current to the future automated functions and associated procedures. We established an intra-service FAA working group to establish future design requirements for the controller suite. Its aim was to provide design guidelines, functional descriptions and requirements for the new system.

As new functions are designed and made a part of the ATC system software, the methods for displaying data to the controller must be carefully evaluated.

Closely associated with the preceding program is an activity to analyze the radar controller information sources, data needs, and utilization of currently available data, and to develop requirements for future system display formats and information content.

Investigation of the controller end of the CDTI-ATC "interaction" loop represents another area of investigation. This program will investigate the changes in controller actions implied by various redistributions of the control functions between the controller and pilot, controller impact and workload

implications of various CDTI passive and active functions and special interface hardware and software design requirements needed to achieve compatibility between the two systems.

Another area of investigation is the use and human factor benefits of the use of color in plan view situation and electronic tabular displays.

Obviously, the impact of increased automation on system safety and efficiency must be demonstrated prior to implementation. Our objective, therefore, is to characterize and measure the impact of different roles for man and machine in a more automated system. As part of the AERA program, we will be using controller sector suites, such as this one, to assist in defining conceptual approaches to the higher levels of automation and will make assessments of system performance at several levels of automation and associated man/machine configurations. Related activities will result in development of a systems effectiveness measurement program. In the area of ATC simulation technology and methodology, there is no currently accepted set of measures of system performance that can be objectively utilized to assess accurately the impacts of changes to the existing system. We have under way, the development of a system effectiveness measurement system for evaluating controller and system performance to provide more objective measures of the impact of change to the system. We expect to develop an ATC experiment designer's handbook which will provide objective measures to be used in assessing the impact of changes to the system.

This viewgraph lists the major activities that make up the FAA's program to address the human factors problem I have discussed. I have touched on most of these areas previously. I would, however, like to highlight the area of computer-aided decision-making as it is fundamental to the proper operation of the AERA function. The concept is based on programming into the computer a data base which will result in intelligent selection of conflict resolution and fuel efficient route profile clearances. The same data base will provide the controller greater latitude and flexibility in selecting tasks to be handed off to the computer as traffic increases and workload builds.

In summary, I have tried to give you an overview of our development program in the automation area and to highlight some of the activities related to the human factors area. As we progress to higher levels of automation,

it is important that we consider the five areas I mentioned earlier, namely:

- o The impact of human errors;
- o Automation approaches to avoid errors;
- o Functions or role for automation systems, controllers and pilots;
- o The evolution of the man/machine interface; and
- o Backup system requirements.

We realize that we are still in the beginning stages of the development process for the advanced automation system, but we are beginning to accelerate this process. Therefore, we would like the workshop session to examine the human factors aspects of future systems, to identify potential problems, to examine our programs and initial conclusions, and to offer us your suggestions for additional areas of research and development and possible changes to existing programs.

Thank you very much.

MR. PORITZKY: Thank you, Neal.

We have a few minutes now for questions, if you have any.

I would like to suggest that since we will have an extended time available for discussions and comments, that we restrict questions after these presentations to questions of information.

We do have some time. So, does anyone have a question for Neal at this point?

Would you please come to the microphone and identify yourself.

MR. MARTY LANDERS: Mr, Blake, did your staff hear anything at all having to do with the Flight Service Automation Program since we are going to be consolidating about 320 facilities into 61?

MR. BLAKE: Well, Flight Service Station Program is quite a bit further along; and, as you may know, we did several experiments, the first of which was to put in to our Atlanta Flight Service Station, really, the first automation of the Flight Service Station specialist function, and we have had several years of experience there, and have been able to derive from that a number of very valuable inputs which are being used in the design of the current automated system.

We also did some experiments with location of facilities, the idea being, if you have a given number of people that might have been dispersed, the service would improve since not all facilities are equally busy.

We have also been running, with the assistance of our Transportation Systems Center and the MITRE Corporation, a number of demonstrations and public experiments on pilot direct access to the computer data base using a variety of terminals and also using the touchtone telephone.

There is a wide variety of human factor type experiments built into that program.

MR. PORITZKY: Yes, sir.

Would you identify yourself and your affiliation, please.

MR. YOUNGER: Abe Younger, American Airlines.

Neal, it seems that -- maybe I don't understand it, maybe we are at cross-purposes, but in your presentation of all the automation that is coming about and in the future, we in the air carrier business are also trying to automate things in our aircraft, one of them being black boxes that will permit us to fly an airplane more efficiently fuel-wise and it seems with your automation we will become more rigid than we are now and we may be at cross-purposes.

I would like your comments on that.

MR. BLAKE: Well, I think that that has been a concern of ours, too that in laying out the design of future automated systems, we have assumed that there would be an evolution in the aircraft through the greater use of computers, and we envision at some point the ability to exchange data between those computers and the ground or traffic control system.

I think our basic desire is to provide the community with a service they would like, and more and more, that is, -- direct routes, optimum altitudes, fuel efficient profiles.

Many times today if you want to file a direct route file plan, you have to bring it down and put in fixes every 200 miles so the computer can handle it.

Also, in the eastern part of the Country, we sometimes can't deal with direct routing during high traffic periods of the day. We think, through the use of higher levels of automation, we can remove these restrictions.

So, it is more flexibility and a better match between the ground automation and proposed air automation.

MR. PORITZKY: Yes, sir.

MR. MATT PARSONS: Can you tell us how the direction center, what is known as the joint direction center, what is known as the joint surveillance system, how that fits into the picture?

MR. BLAKE: Well, as you may know, we have a set of radars which we operate, which are used jointly by Air Defense and by FAA, and we don't see this changing. We will continue to operate in a joint network where that is to our joint advantage.

The information from those radars is fed separately to the different air defense systems and to the air traffic control centers.

We have had, in some cases, some military surveillance positions at some of our air traffic control centers.

We will continue to accommodate this sort of operation where it appears most cost-effective and beneficial.

MR. PORITZKY: Any further questions?

MR. ED POKINSKY: Neal, you talked about the future computer system or the replacement for the present system. You talk about higher levels of automation, and you've got a new concept of AERA on the horizon.

Is there any study or consideration being given to the possibility or perhaps the need for consolidating some of the 20 centers? Have you looked at that at all?

MR. BLAKE: Well, as you recall, the flight service station program started out -- I think the DOT actually started it out and most of the benefits were from consolidation and some benefits from automation. We put the two together; and because there was such a lot of discussion on consolidation, the whole automation program slipped.

So, our current approach is to look at the benefits we will get out of the high levels of automation, but we are not currently looking at any center consolidations. That is not to say we may not in the future, but we are not in the present.

MR. KRUPINSKI: Well, to me you seem to be putting the cart before the horse. You ought to conduct that study now, rather than make some presumption that with AERA you can enlarge the sectors. I think that that is an arbitrary presumption without some kind of a study as to how you would re-configure the centers themselves. You may still need 20, or maybe less, or maybe more.

The second question I have is with the introduction of DARC. You indicated that you were going to eliminate the broad band radar, if I understood you correctly.

My understanding of the Engineering Initiatives Conference was that all of the people -- I think there was pretty much of a consensus that the broad band would be retained until there was some alternative way of displaying weather for the controller on his control scope.

Is it still a firm decision that broad band radar will be eliminated?

MR. BLAKE: The plan is to phase it out.

Of course, the other part of it is to put in a better weather radar system and build around the national doppler radar network.

There is no precise time schedule on when the broad band system will be removed.

We are well aware of the weather problem and we think we are working on a useful solution to it.

MR. PORITZKY: Yes, sir. One more.

MR. ROSS: Jon Ross from the Los Angeles Tower.

Major emphasis of your research and development is naturally on the en route and terminal radar systems.

Have you been looking at all at the extension of the automation into the tower cab, itself, to assist those controllers?

MR. BLAKE: The electronic display system that we mentioned in the case of the terminal called TIDS and ETABS in the case of the crew, is directly aimed at starting to introduce automation to the tower cab. With the advent of the Discrete Addressing Beacon System data link, a number of the functions which have been done manually today may be done automatically tomorrow in the tower cab, and the interface between the tower cab and the terminal and en route automation system will be much improved.

So, I think you will see significant benefits to the tower cab, a fairly sizeable step forward.

MR. PORITZKY: Any further questions?

(No response.)

You think you are going to get a coffee break now, but you are not!

There are a number of things I think you need to be aware of.

The first is that these proceedings, as have the proceedings of the earlier workshops, are being recorded and there will be a record available to you, and of course to us, of these proceedings.

You are free -- and we hope you will -- to make comments and suggestions after these sessions are over, but the record will be kept open.

I want to introduce now a number of the people who are directly involved in these programs so that you can interact with them and chat with them as these two or three days proceed. Joe Del Balzo has already introduced some of the people at the Technical Center, and I would just quickly ask some of the people to stand so that you would know who they are and where they fit.

We start with Walt Luffsey, who is the Associate Administrator for Aviation Standards of FAA, who has expressed a very strong interest and a very strong commitment to get moving, and moving rapidly, on solving some of the problems we have talked about today.

Walt, would you stand up so that everybody knows you.

MR. PORITZKY: The aviation standards and aviation safety side of the FAA house is, of course, directly responsible for establishing the requirements for writing the sensible statements of objectives for the work we try to do on the engineering and development side of the house. Very closely involved in this is Jack Harrison, who is the Director of the Office of Aviation Safety.

Jack is standing back there.

Working closely with him are Cliff Hay, who is in the back, and Guice Tinsley, who is also in the back.

From the Technical Center -- you have already heard the names, let me make sure you know them -- Carlo Yulo, who opened these proceedings this morning; George Long, who is over there somewhere; and Lloyd Hitchcock standing way in the back.

From the Research and Development Service, people who I think are here -- and I hope I am not wrong -- John Bryant, Art Chantker, John Park and Rick Wise.

From the Systems Engineering Management office we have Bill Koch who is also in the back; Peter Hwoshinsky -- he is the tallest guy here; you can't miss him -- and Harry Verstynen, who is the chief of our office at the NASA Langley Research Center.

We also have here from the Transportation Systems Center Jim Andersen.

They are the actors who are very directly involved in these programs, and I think you may wish to talk with them.

Now, a couple of other things.

You wonder why the screen is so small and why there is a gold curtain up here, and I want you to be sure you understand that.

The reason the screen in so small is so that you would want to move forward. There are seats in the front, and we want to have this as informal and as friendly an atmosphere as we can achieve; and we figure if the screen is small, you will move forward.

Now, the gold curtain is for a different purpose.

Several of us have challenged you to come up with solutions to very tough problems, scientific measure of workload, for example -- problems that deal with the issues of complacency, boredom, inattention; problems that are rife in our society, not just in aviation.

Now, if any of you come up with solutions to those problems, we have set a floor show up for you later in the session and that is the reason why we are

in this room. Watch the gold curtain. In the event any of you come up with real solutions to those questions, you will get a floor show!

Watch the curtain. You will notice there are lights back there and people preparing on the assumption that you will make this kind of progress!

Now, before you have coffee we have two more things.

One is that TV Channel 10 I think from this part of the world is here and interested in this conference. During the coffee break I think you will see some of them filming -- I don't know what, but they will be filming -- so I have been asked to suggest that you look impressive for that purpose.

Before we have the coffee break there are some other administrative things that should be said.

I would like to introduce Michelle Lenzmeier who will talk to you about the administrative arrangements.

MS. MICHELLE LENZMEIER: For those of you who haven't already noticed them, there are telephones to the left by the escalators so you can make calls to wherever.

We also have a message board that is directly outside the door. So, those of you who want to leave messages for others, it is there; and also for telephone calls that come in -- people that are trying to reach you -- they will be posted on the message board.

The number here at the hotel, if you want to give it to your office, is 441-4000. The extension where we will be taking messages for you is 4420. The number again is 441-4000; the extension is 4420.

There will be buses to take you to the Technical Center Thursday and Friday and again back here to the hotel after the sessions. They will leave at 8:30 and 9:00. We ask that you be there promptly because the taxicab ride, if you miss them, to the Technical Center is $20.

There will be coffee this afternoon along with some tea, Sanka and soda.

For lunch you are on your own. There are two lovely restaurants here. On this level there is the Brighton Room and on the street level there is the Park Garden. There are also hot dog stands out on the Boardwalk for those of you who would like to get a little bit of fresh air and walk the boards.

There is a reception that is going to be hosted this evening from 5:30 to 6:30 and it is going to be at the Pool Side Room on the third floor, up the escalator one level from this level.

For those of you in the Washington contingent who didn't pay your $15 registration fee, would you please do so at the coffee break? What this $15 registration fee is for is for the buses to the Technical Center and the coffee; and unless you want to walk and drink water, we appreciate your paying the $15.

Thank you. Enjoy your conference.

MR. PORITZKY: Now, coffee.

If you try to be back in your seats at about five minutes to eleven, I think we will be in pretty good shape.

(Coffee break.)

MR. PORITZKY: I was going to make one comment before introducing the next speaker.

The comment I was going to make is that the work on AERA that Neal described, and the work on the Integrated Flow Management System that Neal touched on, is very specifically intended to permit aircraft to operate in the most fuel efficient fashion. I mentioned earlier, I think, that in the manual system we feel there are just too many variables for human beings to juggle in order to provide each aircraft with the fuel efficient direct path that he may wish to fly. It will take automation, we think, of the kind that the AERA work is attempting to create, to permit the kind of flexibility that the air carriers and many other people will have to demand.

The situation isn't quite the same in the terminal area in the Terminal Integrated Flow Process. Again, we would like to provide the most efficient profile and the most efficient arrival and departure path for the aircraft, but in that situation the airport, itself, and its own particular problems of capacity require a compromise between the optimal profile for each aircraft and the total through-put of the airport, itself, which, in some instances -- some 20 or 30 placed in the United States -- represents a limit, in itself, and the challenge is to provide the best balance of optimal airport through-put with optimal profile capability.

Well, you are all settled now, so I would like to go now to a part of our presentation which will deal with the current and near-term human considerations.

Our first speaker is Bob Orr from the Air Traffic Service, who doesn't have the luxury, usually that we have here, because we can talk about our problems at least in these two or three days in an abstract fashion. Bob Orr finds himself on the firing line all the time, so that his perspective is a particularly important one dealing with the problems of performance enhancement and error reduction, which I think is probably a better way of referring to the more loosely phrase "human factors questions."

Bob Orr has been, and is, the Executive Officer of the FAA Air Traffic Service in Washington, and has been since 1971. He holds an A.T.R. license, as well as a Bachelor's and Master's degree in Engineering.

Before his present assignment, he served as a member of the Near Midair Collision Study Group in 1968. Prior to joining FAA, he retired as a colonel from the U.S. Air Force. His military experience included duty as a pilot, Weapons Controller and an Engineer in the initial cadre for the SAGE (Semi-automatic Ground Environment) system.

It is a pleasure to introduce Bob Orr.

MR. ORR: Thank you, Sieg.

Good morning, ladies and gentlemen.

First, I would like to let you know that Mr. Van Vuren, our Director of the Air Traffic Service, apologizes for not being here himself so that he could address you on the subject of Human Factors. He has been extremely busy as Chairman of the Air Traffic negotiating team for the on-going contract negotiations with the Professional Air Traffic Controllers Organization. Moreover, he is now in the process of organizing a rather large effort to conduct a National Airspace Review.

This morning we have listened to various overviews concerning the Human Factors associated with the air traffic system, particularly the excellent presentation made by Mr. Neal Blake.

We in the air traffic system are, of course, most concerned with those which apply to the air traffic controller now!

The area of Human Factors in air traffic has always been, to a degree, difficult to tie down to specific elements which can be dealt with as discrete items. Since the inception of air traffic control, the controller has prided himself on being a very adaptable, flexible, and a pragmatic individual, one constantly ready to cope with a rapidly changing situation. As we more clearly define and structure his control tasks, we recognize that a certain amount of his flexibility has been hindered. At the outset then, we must carefully scrutinize the characteristics of future changes we propose to make in the air traffic control system by bearing in mind all areas of Human Factors in our design efforts.

Today we face a new generation of controllers who have been conditioned by our social and technological advances, to the point where they expect, like many of their peers in the private sector, instant responses to their demands for technical and sociological changes. Thus, the motivation of an individual in his or her approach to the control of air traffic must consider the sociological needs, the adaptation to a changing situation, recognition of his time-off concerns and the Union pressures. As a matter of interest here, we should be aware that the average level of controller experience in our centers and towers is currently 10.5 years. This includes his or her training time as a developmental controller.

Now, the advent of automation has led us toward system refinement and at the same time, has reinforced our realization that the actions and reactions of the controllers and pilots remain the single most important element within our system. We are, in fact, a labor intensive organization whose very existence is dependent upon the consideration and understanding of Human Factors.

Here, I can state with all certainty, that controllers, despite rumors to the contrary, are in fact human. As the prime mover of our system, we measure, review, and analyze their performance in order to design system enhancements and refinements. From an economic standpoint, these enhancements are critical to the aviation community. Fuel conservation and delay reductions are essential not only from a profit standpoint, but in some cases, assure the fiscal survival of our users. The trends of fuel prices are easily anticipated. So are the trends of air traffic services. Each time we see an increase in OPEC's prices we see a corresponding increase in user requests to which we must be responsive. If this were our only responsibility,

our task would be simple. Unfortunately it is not. Fiscal survival must be considered along with physical survival. Safety in aviation is an ongoing concern as we strive to better understand and hence eliminate system errors.

These issues lead us directly back to Human Factors. The sophistication of today's hardware in the maintenance of a safe and efficient air traffic system is totally worthless without the skills and expertise of the human element. We, therefore, attempt to ameliorate the human performance: not to be adapting the man to the machine, but by building the machine to fit the man.

Every human shares common traits, weaknesses and susceptibilities. Next time you're in your neighborhood supermarket on a Saturday afternoon, take a look at the line that stretches back to the frozen foods, and then glance up at the poor soul manning the cash register. That perspiration on the forehead is the same that you find on an approach controller who just accepted a handoff on one too many airplanes. Here, however, the comparison ends, since charging 39 cents for a 49 cent item, and issuing a wrong altitude to an aircraft, hardly equate. Therefore, human error in air traffic control has been our primary concern.

Seemingly minute issues such as headset designs, keyboard layouts, and chair configurations, all add up to the elimination of small irritants which by themselves may seem insignificant, but totalled up, add to a fairly complicated situation. As we look ahead to the future, increased automation, Human Factors will play an even more important role. We've all been exposed to and frightened by the personnel manning our MX missile sites. We encounter the same situation in air traffic control rooms, as controllers, geared to working voluminous traffic, encounter slack periods, and allow errors to occur that would not have happened during busier periods. Without question, an analysis of human errors in air traffic control eventually shows two major causes, namely inattentiveness and the fact that the controller has boxed himself in an error producing control situation.

Even today, automation has taken away the memory joggers which controllers once had. Radar Data Processing (RDP) has made us complacement, where the updating of flight progress strips and shrimp boats used to require more mental concentration. Will Conflict Resolution, Electronic Tabular Display Subsystems, and Altitude Warning Devices add to this problem and make us all the

more complacent to automated radar display data? With the advent of completely automated air traffic control services, what Human Factor designs will help us fight boredom and complacency? Shortly after the Three Mile Island incident the Nuclear Regulatory Agency came to us in Air Traffic and spent several days with us going over the many items that we try for in alleviating the human error. Oddly enough, they have never really focused on this aspect of the nuclear operation that they have so ably put forth technically throughout the country.

When we initially began exploring Human Factors with the MITRE Corporation, the need to educate the controller in the awareness of his own weaknesses became quite apparent. This was our primary consideration when we began the development of a listening and memory course for controllers. The course makes the controller aware of his own weakensses and teaches him to develop habits which replace the manual memory joggers of the past with operating practices designed to preclude forgetfulness in today's operating environment. Specifically, this course is new in the way it is presented. We have developed more videotape scenarios which essentially bring the operational real-life situation to the controller very forcefully and emphasize the needs for him to remember more effectively and to listen more accurately. This is very basic not only in the area of inattentiveness, but letting the controller get himself into a situation that is bound to produce a system error.

In addition, with the MITRE Corporation we have made great strides forward in the development of standard operating practices. In the past, air traffic control has been considered a state of art. "You train me how to be a controller. I will take it from there, fella. Leave me alone. Let the Team Supervisor stay away and let the Watch Supervisor stay away from me. I can handle this control situation."

Now, people handle these situations differently. Situations which will require us to get on the stick and develop standard operating practices.

With the young controller work force, standard operating practices have been accepted and have been developed by them and, to a degree, not only are they a good training device, but, more than that, they are now in our procedures manual and will be complied with as we move forward with standard operating practives in the radar identification, in hand-off, in position

briefing, and particularly in the coordination that has given us so much trouble. between the local controller and the ground controller in the cab. These are a few of the standard operating practices that we have spent a considerable time and resources on developing and will be probably completed within the next two to two-and-a-half years. The Standard Operating Practices, which Dr. Kinney will address, and the Pilot/Controller Glossary published over a year ago, are both directly related to Human Factors. Again, our desired results were to reduce, if not totally eliminate, the possibility of human misunderstanding and error.

The role of the controller has, is, and for a long time to come, will be an important one. From providing a confident and knowledgeable voice transmission, to a calm and inexperienced pilot faced with an emergency; to providing current weather data -- his task is unique.

Believe me, as a pilot, I really welcome, right in the middle of a thunderstorm, to hear that controller come forward with his voice -- not a computer voice, but his voice -- assuring me that they can get me down and through the thunderstorm. This is an ingredient that you people, skilled in the area of human factors, better address as we move further into automation.

One of the largest things that is facing us right now, which was passed over very quickly this morning, however, it was recognized, is the development of back-up systems which are so essential to a system that conceivably, when faced with a failure, puts us in deep trouble around our larger, major terminals.

I, too, to an extent this morning have been guilty of using buzz words. But at the outset, I do recognize and the Air Traffic Control System does recognize that we need specifics in this area of human factors. Specifics on the management of traffic, on how we can reduce delays, on how we can reduce error. But, more than that, I recognize that human factors is such a broad subject that it can, to a degree, cover the entire spectrum from anything where the human element is in the loop, clear back to the feedback system.

Being faced with today's operation, I would request that you try to consider as many of the specifics in our design efforts of the future and our problems that are associated right now, today, that conceivably the human factors experts in this audience could help us with.

I could give you a wish-list, if you will, of things that bother us and I can get into specifics, but, on the other hand, many times specific elements associated with human factors end up being a research and development project. By that I mean in connection with the dissemination that was talked about this morning, a very specific human factor element is the color design of the display. However, I would hate to limit us in our workshop today, in connection with air traffic, that we just concern ourselves with color displays associated with other displays.

So, in this light, I request your input into any problem which you may perceive and your suggestions towards their resolution in spite of the fact that this gold curtain back here has the preparation, and the symphony orchestra to display your resolutions to any of our problems!

I thank you.

MR. PORITZKY: Are there any questions for Bob or comments?

Yes, sir.?

Please identify yourself and your affiliation, if you would.

MR. THEISEN: I am Chuck Theisen from Essex Corporation. When I heard that Three Mile Island reference I thought I would comment on that.

One of the major opportunities it seems to us exists now with the FAA effort on the controller suite design and the new computer program is the avoidance of situations that we found when we did the analysis of the Three Mile Island accident.

We found that there were improvements that could be made in procedures, improvements that could be made in training, but we found that the basic cause of the accident was a design-induced error.

The nuclear power control rooms are absolutely, completely fraught with design elements which are going to cause people to make errors. We think that one of the major contributions that the human factors people can make, in addition to the ones that MITRE has done, is to get into the design of that man/machine system.

I just want to emphasize that I think that when I see the direction that seems to be going and the level of detail and definition that seems to be developing, it is a bit frightening in a sense that there are so many options

which seem to be getting out of the way before we get to addressing the questions of substance such as the human factors people need to address before they can input into the design.

So, I just want to mention that design-induced errors are probably the primary problem you are going to face with these major changes, and these are peripheral to all the training and procedural errors.

MR. ORR: Thank you for your observations.

Design errors are, in effect, very truly a part of what happens in the air traffic control system.

I want to point out that we have a consumer known as the Air Traffic Controller; we give him a piece of equipment and he is probably the most vocal consumer in connection with what is wrong with that piece of equipment, why it was designed improperly "and, God damn it, will you fix my chair so I can sit here in better shape".

So, this type of thing in connection with our design effort, we have a continuing feedback to Mr. Poritzky and his whole effort in the research and development area, which has helped us considerably, which the Nuclear Regulatory Agency did not have: they did not have enough feedback from their operators.

MR. PORITZKY: Any further questions or comments?

MR. HANSON: Howard Joe Hanson, a professional airways system specialist.

An observation from your observation. I am a Certified System Specialist at one time working for the FAA, and many of the design problems that I came to know as a common day occurrence many of our contemporaries feel could have been avoided in the design stage.

Is there any program that will help eliminate through a feedback process future design errors before an individual has to work with them?

MR. ORR: Yes. I think directly right now at this point MITRE Corporation has moved ahead in this area with all the tangibility that we can begin to ask for. The Tech Center has come forward and we now have displays and we have AERA set up as described here this morning. The display set up by MITRE enables the air traffic controller, who is called upon from time to time, to

work this system out there. The air traffic controllers that we have here at the Tech Center are continually a part of the loop that I am talking about in showing our design efforts, and particularly they will give us a hard time not only in the hardware area, but they will show up the errors in software very quickly.

MR. PORITZKY: Thank you.

Any further comments or questions?

(No response.)

MR. PORITZKY: Thank you very much,

I think one observation that might be of some interest is that, as Bob described, we have done most of the obvious things. We are looking for better ways to deal with the subtleties. There is a real dilemma because in a system such as the work that is going on on AERA, if you describe the -- if you ask the Engineering Psychologist or the human factors person or whatever name you like too early, what you get is garbage. You get theories. If you invite him after the design is very far along he says, "Why don't you do it this way?" and "You should start over." One of the toughest problems, in my view, in the AERA system design is to create that right balance of not getting the guy in too soon -- and we tried that and failed -- and not getting him in too late.

The timing becomes extremely important, at least by their track record, if the engineering psychologists are going to be of actual help and not feed us the obvious. I think that is one of the issues -- and it has been one of the most critical ones -- and will continue to be in the area of automated decision-making.

Let me go on now and stay in the area of current near-term human considerations. We are going to hear now about some of the issues that confront the technician in the FAA system.

The presentation will be made by Gerald Thompson, who is the head of the Airway Facilities Service.

Gerry joined FAA in 1962 as an electronic technician in the FAA western region in Oakland, California. He moved into automation engineering at NAFEC in the early seventies as Chief of the Automation Engineering Support Branch.

He then moved up to the automation engineering division in headquarters and in early 1980 to his present position as the Director of the Airways Facilities Service.

He will talk to us this morning about the near term changes planned in the system maintenance philosophy with a focus on the technicians' tasks, training and qualification requirements.

It is a pleasure to introduce Gerry Thompson.

MR. GERALD THOMPSON: It is a personal honor to be on the same stage on the same day with Joe Del Balzo, Jim Bispo, Sieg Poritzky, Neal Blake, Bob Orr, Ken Hunt, distinguished representatives of academia, industry, government and employee organizations and Dolly Parton!

Now, I realize she is down the street a little bit -- I think. I am not quite sure whether she is here or down the street -- but, anyway, I can dream about being on the same stage with Dolly Parton just once!

Probably some of you will say that what I am going to talk about is also a dream -- a dream of how we are going to have to change the way we maintain the airway facilities in the future. Up to this point that is not really a dream, but really a plan -- that will have to evolve over time if we are to meet the needs of tomorrow. With that, I would like to talk about that for a second.

From Neal's briefing you can see the change that is expected in the Air Traffic Control System, and from one point of view we think will happen to us during the 1980's and probably into the 1990's: nearly an entire field system is planned for replacement; that almost every facility currently viewed will be replaced in the next ten to twenty years; that a whole lot of new kinds of systems will also be added. Probably the biggest significance of all of that, even beyond that, is that the user dependence on the systems that we maintain and operate will be greater and greater. As we go through here, I think you will see that, as we talk about a new maintenance concept, that we will have to impose consideration on the way we are going to design the machines if we are to meet the needs as we see it.

Finally, one of the key ingredients we will need is the ability to remotely control and monitor those facilities.

Now, those changes that Neal talked about are largely the air traffic control part of the system; but it is also true in the air navigation, landing systems, communications and all other aspects of the current system.

I might add that the work we have done thus far on what we call the new maintenance concept or maintenance concept of the eighties is, in fact, a direction; we do not have all of the answers as to how that will be done. As a matter of fact, we will need the help of all of you, and including the many field technicians that we have, in developing the finite details on how we are going to execute that project.

To set the stage a little bit to bring you to where we are at, today we have 11,000 people maintaining 19,000 facilities. Those 19,000 facilities are strewn from Alaska to American Samoa, to the Canal Zone, to Puerto Rico and everywhere else in between. We have people stationed at about a thousand locations who go and maintain those 19,000 facilities. It costs us currently about $570 million a year to maintain them.

Let's look a little deeper into that.

We have 11,000 people. Over 70 percent of those 11,000 people are over forty years old. Over 25 percent are over *fifty years old.* Over 60 percent have been with us over ten years. Over 45 percent have held their current job for over six years. This means to me at least that over the period of the 1980's we are going to lose a whole lot of people if for no other reason but retirement.

One of the big problems that we have is to maintain the level of skills that we have in those particular situations. It takes us four or five years to create a new technician of that skill. So, on one hand, that is a major problem to us. How do you get a new group of technicians now to replace these that we expect to leave? On the other hand, it is an advantage because it allows us to bring in a new set of technicians to meet a new work force requirement.

Let's talk about the 19,000 facilities. About 15,000 of them today are electronic facilities. Some of the others are power plants and things like that, but we have 15,000 electronic facilities today. 9,000 of them are vacuum tube technology. We still have vacuum tube technology!

Looking at the 11,000 work centers -- and the definition of a work center here is a word we coin to describe a place where we have people stationed permanently; in other words, that is their resident station -- anyplace like that is called a work center in this definition -- those work centers will vary from one-man stations to stations of over a hundred. Sixty or seventy I think is the very biggest one we have.

Now, the cost. The cost by 1990 is expected to be well over a billion dollars if we don't change something to maintain the mass, as we see it.

Talk about how we took that on or how we are beginning to take that on. In 1976 we established the MPSG or the Maintenance Philosophy Steering Group. We chose two headquarters division chiefs, of which I happen to be one, and eight field division chiefs, and we tried to address basically the maintenance concept we were using at the time and how it would meet tomorrow's needs, and we laid out what were the basic requirements that we ought to be looking at. Essentially, increased demands of vast capabilities; you can take that from two or three different perspectives. One of them is the total number of facilities and a second one is the terms of their reliability.

Now, those of you who are familiar with the computer problem of late will note that I am rather sensitive about reliability, particularly of computers; but there is no doubt in my mind, as we go more and more to machines doing air traffic decision-making functions or even kind of air traffic alerting functions, such as conflict dilemma, that the demand for functional reliability is increasing; and as you go into the decision-making level, that the reliability on a functional plan must approach, if not be, 100 percent.

Now, that doesn't mean that a particular machine must be 100 percent; it means that the function, itself, must be continuous. You can accomplish that by various functions or schemes or redundancy, or you can do it all at the same site by having two of the same kind of gadget, or you can accomplish it by two of the same kind of gadgets at different sites, or you can accomplish it by two different kinds of gadgets either at the same or different sites, or you can put a man in that loop such that a man can replace a machine; but, nevertheless, you must somehow get 100 percent functional reliability, it seems to me, or very, very nearly that, if you are going to go into this kind of decision-making process, which I think puts a new responsibility on airway facilities or at least an amplification of an old one.

No doubt, the number of facilities will increase. Our estimate is now that by 1990 we will have 22,000 in lieu of the 19,000 we talk about now -- increasingly complex facilities. It seems that as we go with the computer -- and we can get smarter and smarter machines -- the machines become more and more complex. There are computers on everything now. Even engine generators have computers on them that control everything from the spark to turning them off and on. So that the point I want to make there is the complexity of each of those machines is rising.

In addition to that, in terms of each individual machine, if you look back 20 years in our lives, most of the facilities were indpendent then; if that facility was out, it affected only that facility and its local environment. What we have gradually evolved into is not a single group of facilities made up of single ones like that, but rather a single complex system, much like a spider web where you pull on one end of the string in Boston and it affects something in Los Angeles: the whole web moves if something happens. So, we now have a super-complex system.

New technologies. As I said a moment ago, we have 9,000 vacuum tube facilities. Just changing 9,000 vacuum tube facilities to 9,000 solid state facilities is a major technological change for us. Now, in addition to that, you add the complexities that Neal is talking about that come with it, and you have an even greater problem of technology.

Finally, the last two that you see here (indicating) are coming true even quicker than I had hoped, but, nevertheless, there is a continual pressure -- and there has been for the last several years and I expect it to continue -- to hold down the size of the work force we have available to do the work and the dollars that it takes to go with that. In our case, while we pay all of the bills like utility bills, rents and leases and all that sort of thing, still approximately 90 percent of our total expenditure is in people. In other words, the cost of the maintenance is, right now, approximately 90 percent people-cost.

Let's look for a second at these two concepts. This is a very simple overview of the concept (indicating slide).

The current concept is characterized by preventive maintenance. First, let me talk about that for those of you who are not familiar with what we do.

We go to a facility -- each of those 19,000 facilities -- on a regular calendar kind of schedule to do preventive maintenance -- i.e., adjust, correct, fix, read meters or whatever -- on the assumption that by going at that interval, we will avoid most failures. The interval will vary from eight hours to several weeks or months depending on the facility in question, but the principal assumption is that by going out at that time in this particular interval you will avoid or find or correct most failures before they occur. That whole process is preventive maintenance. It is not unlike changing the oil in your car. What does the Fram guy say, "You can pay me now or you can pay me later": it is the same kind of thing.

Second, we have a single level of maintenance. That means that each technician is expected to fix whatever facility he has completely at that facility. In other words, he is expected to replace failed components to the piece part on-site, at that location, which means that we provide their parts, tools, test equipment and the like to troubleshoot and fix each of those facilities at the facility. That means spare parts at 19,000 places, that means tools at 19,000 places and the like.

Now, the problem you get into with the modern stuff is the kind of gadgets and tools, and so forth, that you need to fix that thing are very, very complex and very, very expensive, and they also require unique skills on the part of the people to do them; and we see that more and more as we put solid state gadgets into facilities.

Now, I know also from those of you who are equipment manufacturers, the cheapest way to build the equipment is to have the biggest possible board with the largest number of chips on it and do the whole damn thing in one piece. From a maintenance man point of view, that is a very difficult way of doing it.

In addition, we have numerous manned facilities: places where technicians are. For example, we currently have manned locations that run those radars.

What does that mean to you? Right now we have 110 long-range radar sites in the United States, including Alaska and Hawaii. By the end of the 1990's we expect 138 long-range radar sites, including the joint radar system that we share with the military. We have somewhere between five and twelve people at each one of those radar sites. So that we go there from a distance, as an example of what I am speaking to.

The new maintenance concept is characterized by maintenance requirements being determined by continuous remote monitoring.

I think it is important now that I lay out what we are talking about here.

When we talked about preventive maintenance, we talked about how we would go out there once a week, and we did something that would prevent a problem. Now, what we are suggesting is that we go out there on a clock maybe once a month or once a quarter, but then we would have the ability to monitor that facility during that period continuously; and when something looked like it was wrong, we would send someone out at that point -- or was going to be wrong -- and then once the maintenance man went there we would reset the clock for another month or quarter on that basis as opposed to working on a straight calendar schedule.

Multi-level maintenance. What we mean by that is we would no longer fix at each site broken modules, but we would bring the modules back to a central repair station -- and we are talking about a hundred of those or thereabouts -- to do the repairs. By doing that we believe we can afford and set up places where one can fix the kind of modern boards that are being made -- all the eleven layers and the like. Now, it is still true that some kinds of devices we will have to send back to special houses to do.

Thirdly, we would like to limit the number of manned facilities. In fact, we would like to come up with a number of facilities that we call manned and a set that we call remote, and we would like to design those facilities so that they are, in fact, either manned or remote, and the design characteristics of the remote sites will be different than the manned sites.

Now, we are planning to implement this idea over a ten year period, and there are several reasons for that. One of them is that there is no way we can replace the equipment much more rapidly than that as it comes along; another one is that we would like to reduce the impact on our whole organization -- on our work force -- and finally the only practical way to get at it, is to lay it out for a long term evolutionary kind of change.

Now, we would like to do most of the things that we call preventive maintenance today from a distance -- i.e., from some central location. So, with the daily checks and the like that can be done from a central location,

we can determine when things are going to go wrong at the facility, and the like, from a distance, we can take some corrective action from a distance and then dispatch some person to that facility, knowing reasonably well what he is going to face when he gets there.

I would like to talk for a moment about certification for those of you who are not familiar with certification.

Essentially, certification can be described as "I do solemnly swear that this damn thing works"; and technicians are obligated to do that for each facility or nearly all the facilities. In fact, we have a term called "certified facility". He goes there on a routine basis and certifies that this thing is performing the service that he advertised to the user, whether that user is an air traffic controller or a pilot.

What we are proposing to do here is to do that from a distance for a period; i.e., the technician would go to a site as we talked about a moment ago, on a fairly long-term thing, he would certify the facility physically at the site, he would certify the monitoring system at that time, and then for the next interval we would use the monitoring system to certify, and then we would do it again, and so on, over a period of time; but instead of going to the site, as in some cases, once a day, we would hope that we could go to the site once a month or once a quarter.

Consolidation of work centers. One of our major problems has been as we go from vacuum tube equipment to solid state equipment that we find that the workload goes down with it. Essentially, the amount of energy that a technician has to put in to solid state facilities is less than it is in the case of the vacuum tubes. I want to be careful that I talk about the amounts of work as opposed to complexity. The complexity of a solid state device and the difficulty in troubleshooting actually goes up; but the amount of time that he spends with that device goes down.

If you think about that then from a pure workload situation -- let's take the state of Montana where they had all vacuum tube stuff and you had a workload then to support those facilities in the state of Montana; then you find that you got a fairly good distribution of skilled requirements to workload -- i.e., that one technician is not spread all over the place skill-wise. As you replace that with solid state stuff, you find out now that the skill

requirement is the determining factor of how many people you must have because you can't have a guy that is a walking lightbulb, that knows all about computers, that knows all about radar, and all about everything and fixes everything. So, you end up with having a workload problem that is associated with skills as opposed to one with workload. So, to overcome that you have got to, as I see it, have a person responsible for more of a single or related kinds of facilities to address that problem so that you can get the skill requirement and workload back in balance. To accomplish that you have got to create larger pools of people; you can't have them strung out one or two here and one or two there and manage that problem. So, one of the major ingredients in the scheme is a consolidation of work centers, reduction of maintenance cost, which is obvious, which essentially means reducing the number of people and automation of repetitive functions.

Now, I was a technician and I read meters, and frankly one of the most boring damn things I ever did was that: reading meters and filling out logs, and so on. I enjoyed troubleshooting things and working out those kinds of problems, but I certainly didn't enjoy those kinds of functions; and I believe that is universally true. What we are trying to do is to automate as many of those repetitive functions as we can, and, therefore, leave technicians to do work that requires more mental skills and stimulation of mind.

One of the weaknesses I think of the FAA acquisition system over the years has been not too damn much attention to maintainability.

We are very, very good in making the thing work once or twice; we have got a hell of a lot to learn in how to make it work for twenty years and how to fix it easily.

Finally, availability, which is another characteristic. We need a better way of identifying national kinds of problems, trends, design problems. We need to know more about our facilities to allow us to feed back and make them better.

Now, those of you who have been following the press may say that our reporting systems are not true and that we lie and cheat a lot, and I think we have proven that that is not true. On the other hand, I am not satisfied with those systems and their ability to support us in designing systems, nor, second, am I satisfied with the 11 percent of the workload of technicians to

support those systems. In other words, of the work force we have, the workload associated just to supporting maintenance documentation is currently 11 percent of the technicians' time. I would like to reduce that; and if there is probably anything that the technicians would agree to right now it is that he would like to reduce that 11 percent, too, because that is even more boring and a bigger pain in the neck than doing preventive maintenance.

Finally, we have got to be able to flex and adapt that system to future requirements; and, I would add, in addition to future requirements, to local requirements.

One of the things you see when you are trying to build a national system, you are trying to have standardized things. You would like to have, instead of 627 ILS's of which there are 134 different configurations -- I said that for my contractor friends -- you would like to have only one configuration. It simplifies everything: training, documentation, all kinds of support. Everything.

The problem though is if you are only going to have one kind, then it must be adaptable to the needs of Chicago, Atlanta, Los Angeles and West Podunk, and so forth. So, you have got to build facilities that are adaptable for the local needs and still have that standardization to meet that objective; and that does not mean butchering them up to make them fit the need. The minute you do that you are worse off than if you had bought one for that place.

Now, I will go through the three basic tenets of this program.

First is to replace the vacuum tube equipment. We already have underway contracts to replace all 950 of them and we have gotten about a third of the way, to half of the way, in replacing the transmitters and receivers that go with the communications equipment. Some of the major areas yet to go are the long-range radars, the terminal radars or ASR's, the ILS's. We will stop at the ILS's for a moment because I know there are a lot of people who would like the MLS's. I would like the MLS's that were installed in 1943, 1946, and so on. There are 256 of those that are vacuum tube. By the time the MLS is in I don't see how we can support those any longer; we have just got to replace a part of those ILS's. We can argue that for fifty or a hundred years or whatever, but we have got to do something with the ILS.

Finally, the whole teletype network. There is something like 10,000 teletype machines. That is not technically a vacuum tube machine, but that is something that we'd like to do away with.

The second thing, as I said, is remote maintenance monitoring; and I can go on in some length on that, but I think you can draw from what my earlier remarks were as to what we are trying to accomplish with that.

The third one, again, is the reduction of work centers. We would like to reduce those thousand work centers to about three hundred.

Overlaid on a map of the United States is the Alaskan Scheme or the Alaska Plan as it is called where we have to maintain the facilities at Alaska from six locations, and they are shown there (indicating).

Going into that for a second, in the Alaskan case we have people stationed in "the bush", we have to provide houses, water systems, sewage systems and the whole business to keep those people out there, or about $250,000 to maintain a technician in Alaska.

Going on with that, as we reduce work centers, we expect that the work force will gradually come to 10,000 people in the field workforce by 1990.

Looking at our people for a moment, and what do I expect for the technician. The technician will continue to be the major keystone in the airway facilities program. You can talk about that any way you like, but I see no alternative to that. As we talked a moment ago, he will be responsible for a greater number of facilities, and what we are trying to do there is to minimize the number of kinds of facilities that a technician must work on. Responsibilities will become more specialized by the technician.

Also, there is another thought that might add to the ones we talked about already. That is the idea of the very specialized person known to me as a Systems Specialist. We are talking about people who are very, very skilled in radar or very, very skilled in computers or very, very skilled in landing systems and the like. We are also talking about a person that can put that network together.

Training. In addition to all these facilities changing -- we talked about that, and we talked about these people leaving and trying to recruit back behind that -- the training problem is enormous within the next ten years.

Now, the idea of sending everybody to Oklahoma City to school at the academy we have, I don't think we can pull off. So what we have tried to do is develop a system -- and we are in the process of doing that now -- where part of the training -- and I emphasize "part of the training" -- will be done at the guy's home station; and we will try to lay it out so that the academy people will do all of the course development and all of that sort of thing so that we can get a standardized kind of training, but we conduct those things where a man has to physically get his hand on a machine at the local site. Then when he gets to that particular training where he must work on the machine, then we send him to the academy since we do not really want to use the operating facilities as training vehicles; and we use computer based instructions and a lot of other things as vehicles for the training package from the academy to the local facilities or sectors, as we call them, which is the principal AF organization in the field.

Looking more specifically at the technician, we are hopeful that these kinds of positive changes will be made from the point of view of the technician: elimination of repetitive tasks, reduction of unnecessary travel both to facilities and aeronautical center. While the technician will be going to a particular site less often, the travel times will be longer unless we use some other vehicle besides what is known to me as the gray mule. A gray mule is one of these government cars you see which is a Plymouth station wagon. You take out the back seat and you put down a plywood board so you can call it something other than a sedan, so you can pay less GSA rates, and you pound the road with it. We have a mentality at the moment that says the only way to get from here to there is with a gray mule. There may be some better ways. The Alaskans, for example, move people essentially with airplanes and snow machines. There is very little movement of people in Alaska by car; the principal reason is there are no roads. We might learn something from them.

System level emphasis. What we are talking about here is: we think that we put two much emphasis on specific machines when we talk about performance, reliability and all those things. Rather, we think, we should put the emphasis on services as viewed by the customer we are supplying that service to, and then get a rating back from that as to the significance we should place on that machine. I am hopeful, from a technician's point of view, that that will be a more invigorating mental exercise than chasing some particular thing all the time.

Improved scheduling and management of activities. Among other things, I would hope that there would be less 24 hour watches, better use of the people and their time, and hopefully their significance as they see themselves in doing this work.

Engineering support is building up the ability in the sector, itself, to support itself as the first level of support beyond the technician; that is right there and available to the technician when he needs it and it is close enough so that he can talk to it on a face-to-face basis. Then the second level we would build on is a national plane, and try to hook that together.

I talked about training. Along this line we have recently completed a study on occupational attitudes, which some of the people who will be here tomorrow will talk about and how they see some of these things.

Some of the major concerns from a management point of view. One is the problem of retraining, the physical problem of work center consolidation, the relocation of people. One of the major impacts that we expect from this is the relocation of people and the retraining of people; as you move a guy from one location to another there is a physical problem in moving him and that is one of the major impacts. Decrease in staffing requirements and, for that matter, allocations. Travel distance increases; we have to overcome the problem of response time, which means how quickly we can get to a site after we know that something is wrong with that site.

Finally, skill retention. That is a major problem, as I said earlier, as I see it.

I think you can put this whole group of things probably more simply by saying it is the problem of moving today's work force to meet tomorrow's need, while maintaining the system while you are doing it, and ending up with a better one when you get there.

If there is a single problem that faces the challenge of the leadership of AF, it is the "how". That is the most complex one that I see, and I frankly do not have all the answers on how to do that.

Our objectives. Staffing reduction: can we do it without having anyone lose their job by some kind of negative personnel action.

Relocations: we would like to keep them to a minimum.

I think we have covered most of the other statements on that page.

Finally, I would like to conclude with what I started. The individual technician in AF will remain the most important link to insuring system integrity. In fact, his role will probably increase as we go along. I know and I have heard that a number of people believe the implementation of this scheme will create a group of board changing people, and some have even characterized them as monkeys who change boards. Frankly, it is my view that it will be quite opposite. If my experience with computers and gadgets have told me anything, it is that you may need less people, but you will need far more skilled ones and dedicated ones to fix them.

I would like to introduce now the people who will be working with you tomorrow.

The first is Ken Gruz, Deputy Chief of the Programs Division; second, Ed Phillips, Deputy Chief of the Engineering Division; Bob Ring, who is the Chief of the Systems Engineering Branch in that division; and Chet Lament.

They will be working with you as you go through this exercise, and they will be able to talk a whole lot more about this and the problems we have.

With that, I thank you very much.

MR. PORITZKY: Gerry, I think we have time for one or two questions.

(No response.)

MR. PORITZKY: Thank you, Gerry.

The final speaker this morning is Ken Hunt, who is the Director of the Office of Flight Operations, who will touch on the connections between the airplanes for whom this whole mess is designed and the systems that are on the ground.

Ken will talk about the near term impact of automated systems on the pilot/controller interface.

Ken joined FAA in 1960 as an Air Carrier Operations Inspector with the Flight Standards Division of the Southern Region.

A series of increasingly responsible assignments associated with air carrier operations led to the position of Chief, Accident Investigation Staff and then Chief of the Flight Standards Division in the Central Region of FAA.

In July 1979 he moved to his current position as Director of the Office of Flight Operations.

It is a pleasure to introduce Ken Hunt.

MR. KENNETH S. HUNT: Thank you, Sieg.

It is a real pleasure to be here today to give you a few ideas to think about in the next couple of days and the workshop tomorrow and put forth some ideas for you to think about so we can get your opinion on how some of these things in the near term can be handled.

It is a real unique opportunity to have this group of people here today to be able to discuss some of these items.

Ed Yarborough from American Airlines touched on some of the things I would like to talk about today, but I got a few comments here that I would like to give you so that you will have something you can be thinking about as to some of the things you might want to discuss at the workshop tomorrow.

As you know, the interaction between pilots and controllers has undergone considerable change in the past due to the increased complexity in our national airspace system which is necessary to support the growth of air travel. We foresee that this continuing evolution will place even greater demands on the interaction between pilots and controllers in the near future. The rapid rise in operating costs, due primarily to fuel prices, will also create new demands for increased flexibility and efficiency which will have a further impact on this important interaction. Since the primary interface between pilots and controllers currently occurs through voice communications, the probability of a misunderstanding by either party increases when traffic density, complexity of the ATC system, frequency congestion, and requests for additional services increase.

We believe that several factors have a near term potential for placing increased demands on pilots and controllers. These factors include:

1. the increased availability of automated equipment to optimize aircraft performance and to minimize operating costs,

2. the increased use of automated equipment by ATC units to provide improved ATC services,

3. the increased complexity of our national airspace system which is necessary to continue to permit safe and efficient operations as aviation grows, and

4. the need to enhance flexibility and efficiency in the national airspace system to minimize the impact of rapidly rising fuel costs. The rate of the rise in fuel costs will probably be the pacing factor for the magnitude of the demands placed on the pilot/controller interface in the near term.

To give you a clearer picture of how this interface could be impacted, let us discuss some of the types of airborne equipment which are being installed in current aircraft.

Performance Management Systems (PMS) and Flight Management Systems (FMS) are installed in a significant number of air carrier aircraft and the number of these systems in use can be expected to increase in the future. These systems present information for either manual or automatic control of the aircraft to optimize performance and to minimize fuel consumption. These systems can be used in the climb, cruise, and descent phases of flight. However, the greatest benefit from the use of these systems in our domestic environment can be realized in the climb and descent phases. Unfortunately, many pilots now regard these systems as "frustration meters" because they vividly depict the fuel penalties which occur when the flight profiles assigned by ATC are not optimum profiles.

The major impact that the increased use of these systems will have on pilot/controller interactions will be an increase in the number of requests for optimum flight altitude, for descents at pilot's discretion, and for changes in cruise speed.

Sophisticated automated navigation systems, such as VOR/DME RNAV, OMEGA, and INS, are also becoming more available in the U.S. Fleet. Some of these systems are certified in accordance with Advisory Circular 90-45D and may be used as "Slant Foxtrot (/F)" equipment for point-to-point navigation in areas without radar coverage. Additionally, an increasing number of aircraft are being equipped with Omega Navigation Systems which normally cannot be used as "Slant Foxtrot" equipment. However, the Omega equipped aircraft do have the capability to navigate from point-to-point with high accuracy. The use of

this capability in a radar environment can significantly improve operating efficiency. We have been using the point-to-point capability of INS in a radar environment for many years and we believe Omega and Omega/VLF equipped aircraft could be operated in a similar manner. Since Omega systems offer significant cost advantages over INS, we expect the use of these systems to proliferate in the near future.

The major effect that the increased availability of Automated Navigation Systems will have on the pilot/controller interface will be an increase in the requests for point-to-point clearances to minimize fuel consumption and reduce en route flight time.

As our national airspace system becomes more complex, the pilot/controller interface will also become more complex unless steps are taken to minimize the impact of these changes. The assignment of discrete transponder codes to individual flights represented a step in the right direction to enhance this interface. However, additional changes will be necessary in the future. For example, the number of frequency changes required, especially during the high workload periods associated with climbing and descending, has increased as our ATC system has grown more complex. Since the probability of misunderstanding is enhanced during these periods, we believe that any significant increase in the number of frequency changes required during climbs or descents will place additional stress on the pilot/controller interface. If further sectorization, vertical as well as lateral, becomes necessary within ATC units area of responsibility, we believe that the impact of the increased number of frequency changes created by this action should be carefully evaluated for the effect it will have on a pilot's workload and his interface with the controllers.

Furthermore, we suggest that near term improvements can be made to ATC procedures which could reduce the number of voice contacts required and thereby enhance the effectiveness of interaction between pilots and controllers. One means which could be used is to increase the use of simple, straight forward departure and arrival instructions, such as profile descent, STARS and SIDS, to continue to reduce voice communication requirements to a minimum. Another means could be to closely review our current procedures to determine if some of our voice communication requirements are really necessary for safe and efficient operations. We also believe that it is necessary to continue our efforts to develop other means which can be used in the future to supplement

and, in some instances, replace voice communication for routine transactions between pilots and controllers. Although this is a long term project, the "spade work" must begin soon if significant increases in the complexity of the ATC system are anticipated.

In summary, let me stress to you that the increasing use of automated systems on board aircraft, and the increasing complexity of our ATC system, as well as, increasing fuel prices, will increase the demands on the interface between pilots and controllers in the near term. Any changes to our ATC system which increases the complexity of the system should be closely evaluated to determine its impact on pilot workload and the critical interface between the pilot and the controller.

Thank you very much.

MR. PORITZKY: Ken, we have time for a few questions.

Yes, sir?

MR. CARSON: Phil Carson, FAA Retired.

I am wondering if anybody has looked into the possibility of automatic frequency changes based on the controller and data link?

MR. HUNT: Yes, sir; many times over the years, and I suspect in time it will show up.

There is no technical problem obviously for doing it, there is an equipment problem in the airplane, but I suspect in the years to come we will see it.

MR. YARBOROUGH: Ed Yarborough, American Airlines.

An observation. I did like Ken's speech, and I hope that the R&D and A/P people listened to him.

MR. PORITZKY: Other comments or questions?

(No response.)

MR. PORITZKY: Ken, you got off easy!

You think you are going to get lunch now, but you are not really -- not quite yet. There are a couple of things I want to mention to you first.

This afternoon we will have presentations first by three other organization representatives, not FAA, and then we will hear presentations from several of the organizations that have a strong impact on the kinds of things we are talking about.

I would like to invite you, if you wish, this afternoon before the workshops, to make a more extended presentation; I wish you would let me know -- identify yourself and let me know approximately how much time you would like to have, and it would help us organize things a bit. You don't need to do that. If you would simply like to comment this afternoon, even in an extended fashion, you are more than welcome and the opportunity will be there.

Let me challenge some of the people here who have not indicated an intention to make a presentation -- and I am thinking particularly of the people from academia -- to talk to us and share with us their thoughts on two areas. One is the basic question of complacency, inattention, boredom; and I think we would all be interested in knowing what is going on in academia in other areas to come to grips with basic information in that area.

Closely related to it is the question of technology transfer.

If you listened closely today to the comment from the gentleman from Essex about the Three Mile Island control room, he triggered me to a kind of interesting question. FAA has been looking at this problem for a long time, yet, I see, as the gentleman indicated -- and I can corroborate it to a small degree -- that much of even what FAA has learned in this area clearly has not been picked up by others. All you have to do I think is look at some of the metro systems and the very strange designs that are used in those -- the nuclear energy area -- and it makes me very nervous that the technology transfer, from what FAA knows, or thinks it knows, to other industries, seems to be very poor.

The corollary I suspect must also be true. There are things known in other industries - and we have done a little looking at this - that we don't know about and that the transfer perhaps is not working in our direction either. Any light that the people here who viewed this issue broadly, perhaps from an academic or consultant standpoint, most assuredly would be welcome.

So, think about it over lunch and come back and tell us, and share with us, your knowledge and understanding of these problems and any others you may have.

The time is now 12:23 by my watch, which is probably good for plus or minus two minutes.

We will reconvene in this room at 1:30 sharp.

I hope you enjoy your lunch.

(Luncheon recess taken.)

SESSION II

(May 13, 1981)

MR. PORITZKY: We will continue with the afternoon session. This morning you heard a perspective of, as FAA sees it, some of the problems which we are here assembled to discuss. This afternoon we are going to change the perspective a bit and we will hear from the user community. But, before we do, we will hear three presentations by agencies with whom FAA works very closely. The first is the MITRE Corporation which is the organization which is working with FAA on a number of areas and, most particularly, the automated en route systems, an automation effort that was referred to several times this morning. MITRE has also been involved with, particularly, air traffic service and Bob Orr, in much more near term firing line kinds of problems. Much of that work has been done by Dr. Glenn Kinney who will speak to us a little bit about his perceptions and insights into a number of these areas.

Dr. Kinney has had 26 years of experience in man-machine engineering in our air defense system, in several other air force systems, and the air traffic systems, as I have just mentioned. He received his doctorate in experimental psychology from the University of Washington in Seattle in 1959. He has worked on human engineering problems and has been involved in the human senses with emphasis on vision and on equipment configuration, work-station layout, task integration, voice communications, visual display quality and work environment. Needless to say, he has many publications, and I have heard Dr. Kinney speak before. I think you will find his views most interesting and most enlightening.

Dr. Kinney.

DR. KINNEY: Thank you. As Mr. Poritzky pointed out, there is a very large amount of human factors kinds of work going on at MITRE supported by the FAA of which I will talk about only a small part today, although I think it is worth reporting. It all began about April of 1976 when the Air Traffic Service asked MITRE to form a study group and spend about a year and a half helping to identify the causes of System errors which could be attributed to people, particularly controllers and supervisors, and to try from those observations and findings to recommend remedial actions which could reduce the frequency and System Errors in traffic control. Now, it turned out to be concerned with far more than just System Errors. So, I don't want to give it a flavor of just

that kind of thing. As you will see, it has more to do with everyday operations, with the fallout, hopefully, of producing System Errors. But, I will talk about that and then I will want to tell you something about the work on color displays that is being done and about the listening and memory course, the remembering and listening course that you have heard about, to give you a solid feel for what that is all about.

We formed a three man study team to do the System Error Study, and we did three things: we looked at what they called the system effectiveness information system which was a computer data base of findings of System Error Review Board Reports. Now, for those of you who are not too familiar with this, a system error for our purposes was any time an airplane came closer to another airplane than the minimum separation standards which applied at that time. He could come closer also to terrain or to prohibited air space or to objects on the ground, although most of the incidents that we look at were airplane and airplane incidents. So, we looked at the System Error data base, we read the System Error report files. These are generated at the facility and approved by the facility in the region when a System Error is reported and it is determined to be a reportable incident. That System Error is investigated by the System Error Review Board. They simply did a final report which was put in this or in a file at FAA headquarters. We looked at that file and spent a lot of time reading the reports. Those two things gave us a pretty solid feel for the kinds of things that we thought were underlying factors and basic elements in the occurrence of System Errors. But we found those two sources incomplete and decided that it would be best if we went to the field and sat down with controllers, plugged in with them and watched them operate and we did that, also. We went to four centers and four terminals and we spent two weeks at the centers and a week at the terminals. There were three of us and we interviewed people, talked to the management, looked at their air space. We looked at the System Error handling and reporting procedures, attended System Error Review Board meetings and talked to every level, specialists that were in the facility. We spent time talking to regions about the problem and, of course, talking to people at headquarters.

Now, at the end of that we wrote a report which was published in December of 1977 in which we made specific recommendations as to what might be done. We ended up concentrating on controllers and supervisors, as I said, but

specifically while they are on position and working. We looked -- we did not look specifically at things like the sex of the community, relationships on morale or we didn't look at specific labor-management issues unless they became tied to something that was happening on position. So this was a working controller, a working team supervisor type of study. We didn't study stress because the System Error reporting system did not indicate that it was a major cause of System Error. We know that stress is an issue in the service, we know it is a controversial issue and we know work needs to be done, but for our purposes we considered that largely outside our interest. We didn't look at morale or anything having to do with social or clinical aspects of psychological adjustment. We looked at performance on a position and we ended up concentrating on the things I am talking about because to us they turned out to be the most important elements in what we were trying to study.

Along with things we recommended, the most important ones, it turned out were the absence in the air traffic service of specific explicit detail working habits and practices, the standard operating practices which Mr. Orr mentioned earlier. There is a handbook, and the handbook allows quite a freedom of interpretation as to exactly how a controller should write on his strips or speak to another controller or look at the displays or talk to the man next to him; all these little fine details of the way he does things. We found these to be highly varied among controllers, naturally, because that's the way the system grew up. We appreciated the value of standardization and we recognized in the behavior of many controllers what to us seemed to be highly commendable work practices and habits. So we said you should develop what we think of as a set of standard operating practices to be made directly in the handbook to guide controllers, simplify training, simplify proficiency evaluation, reduce communication timing from controller to controller by standardizing the language, simplifying the words and reducing the amount of verbage, as they call it. They don't say verbiage, they say "verbage" which goes out over the telephones, the interphones primarily. We also looked at the pilot/controller communications and realized, there too, more standards were required. So that was the first thing we sent out to be done. We also said that we saw a need to educate controllers on the capabilities and limitations on their own senses and their own abilities. Now I am not talking about all controllers. What I am saying is that among the controllers in the work force there was a

tendency to overrely on unneeded memory in a situation which very easily interferes with trying to recall dynamically changing complicated flight and operational data and that led to the remembering and listening course that I told you about. So, we also recommended that some standards be developed to help guide supervisors on the job, some things be done to standardize the way they spend their time, that more can be done to improve their training courses and possibly something also to help them help their supervisors in their proficiency evaluations and there is an effort going on in that area. But, it hasn't really gotten off as far as we are concerned; we don't find ourselves as deeply involved in that right now as we do in the other two, so I will spend my time on those.

Now, when we told Air Traffic Service the idea that there should be standard operating practices, what they did was discuss it among themselves and then they called in a group of ten controllers from the field, I guess six controllers, two team supervisors and a couple of specialists. They were called in from all over the continental United States for a two to three week meeting and they were presented with all this data and asked what do they think, what do we need? Well, they engaged in two weeks of very friendly argument, as you can anticipate. As a matter of fact, it looked like we were going to have a knock down drag out fight there for a while, but they are very good at talking that way to each other and putting up with it and, at the end of two weeks, their briefing to the Director of Air Traffic Service was that standard operating practices be developed and that they be developed in detail and that they be developed by controllers and that they be made directive specifically about being added to the handbook. They also recommended that corresponding changes be made in other directives, facility directives, facility handbooks, and that sort of thing. In addition to which they identified key areas where they thought standard operating practices would pay off first, big areas which in their way of thinking needed attention immediately. Their products were then refined and a second group of controllers was called in, about twenty people this time from other facilities and other regions, and they went over what the first group had done and confirmed most of it and developed a shopping list of some thirty-odd items that they thought should be subjected to the treatment that would result in the standard operating practice.

So, Air Traffic Service wants the project largely under the manpower branch, AT-14, in which controller working groups were called in, standard operating

practices were drafted, used and refined by field teams and then put out as candidate standard operating practices. These are, of course, reviewed by the standards' people, by AT-300 and other agencies to be sure that we haven't done something legally irresponsible. Then, at selected facilities we asked the controllers to voluntarily try out that way of doing things in actual practice.

The first one was tried out at Cleveland Center and Cleveland Tower, Fort Worth Center and Dallas Fort Worth Tower and it was about a one month period in which the controllers were asked to try this out. They were interviewed before the test period to get their ideas on the topic and they were interviewed after the test period to get their reactions. They were given check sheets and answer forms and materials to look at and check in and turn in to us. The supervisors were asked for their opinions, the facilities, the regions were all asked for theirs, and all these inputs that were given to us ended up in a polished and tested version of what the standard operating practice should look like. This also went around the usual alphabet in the aviation community for review and comment and as much as was feasible these reviews and comments were incorporated. In other words, it was handled just like any other change to a regulation handbook. Then a date was fixed by which publication and circulation could be completed.

Now, the first SOP was on the transfer of radar identification and referred primarily to the coordinations between controllers for hand off and point out and what we call a traffic action which is one controller telling another controller about some traffic which is a factor in what he is doing. If you want to see what these look like, the transfer radar identification, SOP is appendix five in the handbook. It contains a detailed specific step-by-step procedure initiating controller and the receiving controller: first he does this, then he does this, then he does this -- he or she -- and then this is done and that's the end of it.

It's specific down to the exact phraseology to be used whenever exact phraseology is required, not only to initiate the action but to indicate that the action is completed. After that one was put out, it became effective in March of 1980, as I recall, there was a second one that had been the subject of some considerable interest and this is the position relief briefing and the position relief.

Controllers relieve each other on position frequently on a shift. At the shift change everybody in the facility undergoes some kind of position relief and goes home. During this shift they relieve each other. They don't stay on position for the whole eight hours as you must surely recognize. Indeed, some facilities at some position observe as many as eight or ten reliefs during an eight-hour shift, depending upon what happens. They might combine sectors or decombine sectors. Position relief is a constant ongoing operational event and this SOP specifies the steps by which the relieving controller will familiarize himself with the situation, talk with the controller being relieved, and then the controller relieves and he will stand by afterwards and find out whether or not the relief process is completed before he leaves. Now, all of these kinds of things -- and I want to stress this -- the transfer radar identification in the position relief, these came from controller practices or closely copied controller practices at their recommendations which we could relay, go along with, as being well worth trying out. So they are not something that some outside person came along and said, "Here's what I think you should do." They are things that are generated by controllers, tested by controllers and eventually implemented by controllers. That's in appendix six of the handbook if you would like to take a look at it. It also contains some changes in the facility handbook requiring the facility to supply the materials required to support the position relief process.

Other candidates that Mr. Orr mentioned include one which is almost ready to go called "Altitude Verification," which standardizes for the controller verifying aircrafts altitude and the next one after that is the use of altitude recorded automatically, mode C, and this specifies when and how to validate mode C and when and how to use it. Again, all these things came from controllers and they were tried out in Jacksonville Center in Jacksonville Tower.

Then, other candidates down the line include "Local and Ground Control Coordination" for moving airplanes around on the airport surface. As Mr. Orr mentioned, this shows up frequently in incidents and other events of an undesirable nature, shall we say, which occur in terminals. We are looking also at local control traffic management. Many terminals today have facilities by which the controller operating the local control position can keep traffic as traffic. He has strips he can write on or he has a note pad or something of

that sort and, again, the philosophy here is the same as it is with the other SOP's and that is to find out what good practices are in the field that we know work. If you can improve a little bit, okay. Otherwise try to get all facilities to use that kind of process.

So, as you can see, the effort really is to standardize some important aspects of controller behavior so that all the controllers are performing pretty much the same sort of things.

Now, if you look at facilities which are very busy, you will find most of them are pretty highly standardized. Chicago Air is an outstanding example. So, we weren't at all worried about whether or not standardization was the way to go as long as you didn't overdo it.

So, that's the SOP project; it's an Air Traffic Service project. The number of people involved in it outnumber the MITRE people by three or four hundred to one since we have had the participation of something like 1800 controllers so far in this sort of thing in which we think about 1200 participated in some significant manner. That's not counting the working groups themselves. So, that's what that is all about.

Now, the listening and memory course -- again, many controllers use very explicit work habits to try to remember what is going on. They mark their strips at the right time, they move their strips around or they mark their note pad or mark a piece of paper or tell somebody to do something. They don't rely heavily on recall, pure unaided recall memory, and when they listen to something they try to connect what they hear to what they have already done. If they are familiar with their strips and hear a call sign, they are used to looking at the strip to be sure they heard a call sign that was there; if they are saying something out they listen for a readback and look at something and try to connect it up. So, this course now is to try to show controllers what other controllers are doing. To show them how they are doing it and how it helps them avoid inefficiencies and this sort of thing. The course -- there are three courses so far, "Terminal Radar," "Center Radar," and "Tower Cabin." Each course consists of ten pairs of little scenarios. In each pair the first one shows the controller doing something in a similar situation. This will be on a TV tape and the first tapes are being filmed -- if you want to call it that -- this week at the radar training facility at the Academy in Oklahoma City and we have a Dr. Glennis Bell with us who brought the scripts together

and is down there with AT-14 now and people from the facilities and people from the academy, instructors, to try to put this thing on video tape. In the first of each pair the controller does something and it makes him later, he makes an extra phone call or makes an extra radio transmission or changes something else and he realizes that he could have avoided that inefficiency if he had done things differently to start with. There are no incidents, there are no system errors. The controllers that play the parts are -- they look just like ordinary real controllers doing things. They don't look foolish or embarrassed or stupid or anything because essentially they are not. Then, the second half of the scenario the scene is repeated, the air traffic situation is rerun. This time the controller does something which the controllers frequently do and he avoids that inefficiency maneuver, that cancellation, that maneuver on the part of the airplane or anything else. The lesson is: there are things controllers are doing which, if other controllers would adopt, would make things easier all the way around and the things that the controller does is to follow what we call guiding principles. When the controller says, all right here is a guiding principle, I think there should be organ music in the light from above so we may change the basic guidelines or something, but they are simple little things like memory joggers, should be easy to do, easy to learn, they should be durable, that is it shouldn't wipe itself out without your doing it yourself, it should be connected to things, it should enable you to reconstruct the sequence if you were interrupted while you were doing something -- and that happens routinely, of course.

The listening part of it, it says connect what you hear to what you have got. That good hearing plus a connection makes good listening. That's what makes this course so much different from the usual listening and memory course. It's tied specifically to detail things that controllers do which they have found through experience help them remember better and help them listen more accurately, as Mr. Orr put it. So, that's what that course is about. Now there are plans, when we know a little bit more about how to do this, and we are learning the hard way, we have Southern University on contract to help us -- the FAA has the contract not MITRE -- we have the academy helping us. The actors in the scenes are all controllers or academy instructors. Right now we couldn't get too many controllers, but there is a narrator in each of the courses and the narrator is an active controller. We wanted it to sound like a controller talking to a controller about things that interest controllers.

That's what it's all about. It is not a big polished show with music and stu‾f like that. In fact, there is no music at all. It's just a plain and simple slide. The theme is, "If something like this ever happened to you." Now, what Dr. Bell did when she got her script drafted and approved by headquarters was circulate it among the various facilities in the environment in and around where we are and she went to these places, sat down and talked with the controllers about whether it was good, bad, or indifferent; she incorporated the changes they recommended; she sent it out to the Academy and to Southern University and to the controllers who are going to be the narrators and actors and asked for their inputs and made some significant changes. So, she has brought together opinions of what controllers think ought to be done because it is a controllers' course for controllers. I hope that you are catching the theme here. It's controller involvement with headquarter support and expertise like we can bring together that makes this effort as interesting, I think, and as rewarding as it is to me. So, those two things comprise most of our effort for Air Traffic Service. There are other things that we have done to fight fires from time to time, but I want to tell you also about the trials which are going on in Washington Center, in Leesburg, Virginia where four color tubes, spike tubes, have been installed at the PBE position in one of the areas and the controllers are asked on a voluntary basis to use the four color display for a period of 120 days. If they started on schedule they started yesterday and the tracks which are assigned to them are in the green, the tracks which are not are in yellow as are the radar data, the background information, the airways, that sort of thing are in orange and the weather display is in red. The reason that was done that way is that it requires no software changes in the computer. There are other schemes for assigning colors which could have been tried if we could have had the time and the money to change the software.

The controllers are all thoroughly briefed. They can -- oh, another one of the things they can do is change the shift and go back to an all green display like they already have at any time that they want to. They are not required to sit there and work the color display unless they want to. They have some adjustment over the brightness of the colors and some over the yellow and the orange hue that they see from the display. They can't change the assignment of colors to categories. After two weeks there will be some inter-

views with them to see how things are going. Every two weeks there will be a test period that will take place. There are interviews, forms for them to fill out, there are questionaires for them to answer, and then at the end of it we are going to sit down and talk with them about a variety of different kinds of things which we feel their experience will enable them to answer better than they can answer now. The report on that set of trials will be published by the Technical Center and the triplicate report is to be published by MITRE with AT coordination, of course. We are going to try to say what they learned from those Washington trials to guide us in what might next be done, and follow onward but, most likely I suspect be done where a simulation capability exists such as here at the Tech Center. We got involved in that because earlier we had written a report on color and air traffic systems.

I had been interested in color vision and vision as it applied to systems operators performance for a number of years and when they asked me if I would like to write a paper on color I felt like the musician who has gone to a party and when they ask him to play he breaks out his harmonica and his music and he is already to go. So, we did a research, brought it up to date, and wrote a report which is available, as is the other report. What this report says, essentially, is the capacity for a human being to process information via color is usually overestimated not so much for each individual as for a large work force the size -- well, like the one we have in the air traffic control system.

Normal colorvision is not as fixed a phenomenon as most people think. There are possibly some problems with color blind people, too, we don't know too much about that, but we do know something about color-blindness and we do know there are some people in the air traffic control work force who have waivers and have not passed the normal color vision test. But, if you were to look at the literature which describes the way the human senses work you would soon come to the conclusion that there are specific things about the human visual system that would cause trouble if you weren't very careful about how you generated the colors on the display and I mean very careful. A detailed analysis, if you want to take a very careful and cautious point of view, means there are probably only three to four colors that you could get away with particularly if you wanted the color itself to convey some information, to be absolutely identified as that color when it is perceived. Probably -- and I think this is being a little bit optimistic and certainly speculative -- but

if you have a nice saturated green, a pretty decent orange, a pretty good white and maybe a yellow -- but, you might be stuck with three. The reason for this is that if you generate colors by generating different combinations of wave lengths what you find -- and I will show you this effect in a minute -- is that very short wave lengths cause problems for the normal human eye. It can't focus on short wave lengths. If you use very long wave lengths it requires time to accommodate and you can't shift rapidly back and forth. So you can't use the short wave lengths most of which give you blues if you have blue capability. You really can't use the long wave lengths because they require focusing time and probably would slow people down although we are not quite dead sure. You are stuck in the middle. If you use one that has no color at all, white -- and that's a loosely defined term -- and then you try to provide a yellow and an orange, what you are going to find is that the yellow and the orange are different for some people and the yellow and the white won't be. So you move the yellow over towards the orange so that you can tell it from the white and then you have people who can't tell it from the orange. So you say, let's put in a red and move the orange up next to the red and you have some people who can't tell the difference between the orange and the red. If you move the yellow too far over the other way it looks like it is green. So, you are kind of stuck in the middle. Well, that's a very conservative outcome. It's disappointing and it's true. What we hope is that the Washington trials will tell us more about this and we can, in the meantime, study more and see if there aren't some ways color can be used to help controller performance. Again, I am not considering things such as the beauty of the display or the satisfaction of the man who has the job who works with the color display. We are looking at specifically how performance might be improved and we are going to try to see if there isn't some way we can find out how a work force like that can be provided.

Let me show you some of these effects here, just briefly.

(Whereupon there was a slide presentation.)

The wave length effects have to do with the focusing characteristic of the eye. What I have here is a display made up of black film with transparent lettering on it behind which I have attached celophane tape, some Kodak wrapped in gelatin filters which control the wave lengths of light which comes out through the letter and we have some neutral density filters which are also there

to make them equally luminant. Now, they may not look equally luminant but that is because there are individual differences in the sensitivity of these wave lengths. If you don't think those are all in focus, you are invited to come down here and take a look. They are all from close up equally sharply focused. However, if you will notice, many of you, the blue is fuzzy. Am I right? Anybody out there for whom the blue is not fuzzy? Well, the reason for that is the effect here is exaggerated because of the distance between your eyes and the screen. If you sit up closer, in fact I am right up on the scope up here at 18 inches, you would find in fact that disappears. But however, for some people it remains and you simply cannot focus on it. The reason for that -- and I will give you just a brief lecture on the human eye -- if I tell you something you already know please forgive me -- but the eye is not like a camera. It doesn't adjust focus by changing the distance between the lens and the sensitive retina in the back. It does so by changing the shape of the lens and we call this accommodation. If you have an object illuminated by green light as you see here, which means wave lengths in the middle of the band of yellow and white, then the eyes normal accommodation range will bring that image to focus on your retina for distances all the way from a foot unless you are not wearing your bifocals, out to infinity. However, if you illuminate it like this with short wave lengths the eye tries to accommodate but because blue is in the short wave lengths the image will fall short of the retina. What does get back there is fuzzy, so the eye tries to accommodate by changing its focal length to bring back that image back to the retain and it reaches its limit before the image reaches the retina. That's called induced myopia. Its independent of colorblindness, it's independent of color vision, it is dependent only on the wave lengths and it has been known for a hundred and some-odd years and there is nothing you can do about it except to put a negative lens in front of the eye. If you do that the short wave lengths are brought back on the retina but now you are not accommodating the other wave lengths so you have had it or, as the controllers say, "Down the tubes with that one."

Now, the long wave lengths require accommodation in the other direction. If you look at the green up here for a while and then suddenly shift over to the red you may notice a delay between the time that you shift and the time that it comes clearly to focus and then if you look back to the green and you

will find a shift or a delay there, too. That delay, like these other effects, varies markedly from person to person. It's a function of the age, unfortunately, because as we get older not only do our joints get stiffer but so do our lenses and they won't change shape rapidly enough. That's why you have to keep pushing the newspaper away from you as you pass forty. They are all prefectly normal nonpathological effects in the human eye. Now, there is another effect that happens on color displays. If you look at this in that top pair the -- this is from the National Bureau of Standards so you know it's got to be all right -- nobody fools with them -- the two grey squares on the top are not only the same size but they are the same pigment and the two squares in the middle are also the same size and the same pigment as are the two ones in the bottom. But, they don't look the same and the reason is that the human nervous system gets all fouled up because of the surrounding color. That's called color induction and there is nothing you can do about it. That's the way the system works so if you have a color display and you look at a color surrounded by a color the one on the inside cannot be independently controlled, that is controlled independently of the one on the outside. If you have ever looked at a weather radar display made up like that the little box in the middle is sometimes very difficult to identify and that is probably because of this phenomenon.

There is another one I am going to show you. I took these color slides on Kodachrome film in sunlight and the book that I took them from is here if you would like to come down and take a look at it. The same effect can be seen on these pages which says, "National Bureau of Standards" right on the front.

As you can see, the technical application of color poses some problems that need careful attention and careful work. That summarizes the two major projects that we are engaged in; the first is primarily Air Traffic Services, the second is Systems Research and Development Service. The Office of Administration Management also supports us and has from the beginning.

Now, one of the things that Mr. Blake showed you was some tan consoles. Did you see that one up on the tables with a chair in front? Well, those are facial mock-ups that we have constructed in our test bed, our AERA Test Bed at MITRE. Those things are sitting in our cafeteria, as a matter of fact. They weren't complete at the time we took those pictures, but we wanted some-

thing to show so we were happy to make up these slides. You saw also the other mock-ups that are here at the Technical Center and you saw some that were just consoles standing there with no tops on them. Well, the consoles that we have, if you noticed, have an overhead on them. That overhead can be removed and the work benches will be arranged and the consoles can be set up in a semi-circle or in a line or in pairs or one or two or three of a kind, to mock-up any one of a number of various concepts as to how the SEPTA scenes might be laid out. The ones at the Tech Center showed them in a fixed situation whereas ours are more rubbery. We can move them around and these show you the shape of the console in which we are going to mount the facilities in the AERA Test Bed which is in the basement of one of our MITRE buildings. This Test Bed, as we mentioned to you before, is intended primarily, at least at the beginning, to provide us an opportunity and a facility for testing on various kinds of concepts and ideas as to how controllers and supervisors possibly might use a system like they have a system. We need a great deal of time and effort to be spent on what kinds of experiments are worth doing. Can information be obtained from this type of laboratory to guide more elaborate and more detailed investigatory activities elsewhere? What kinds of things do we now know controllers might do in a system that we can try out here, if not in real time then at least in simulated real time and find out various sorts of things that can be screened out as probably troublesome, or kept as candidates or future studies or future application. There are all kinds of things that we can try and we are in the process of preparing a report for activities that we will pursue in that laboratory or test bed next year. We can try out various kinds of strategic things such as planning activities, metering, and we can try out technical things such as separation services, pilot requests, flow control, that sort of thing. We can combine various sorts of emergency processes, how might a system like AERA, with considerably greater computer capacity than we have now, much more improved man-machine interface equipment, and a properly laid out work station -- how can that be used and help controllers handle emergencies? We have independent support things such as the position relief, such as maintaining system status information so we know what runways are out, or what the weather conditions are and so on. We can look at selected options and because we can pull a top off or put the top on we can look at various transitional concepts and, again, that's just the very beginning. What you saw were the first official mock-ups of the way we

thought we would like to initially mount the equipment that is connected to the computers and the test bed. So briefly, that's most of what we are doing. The listening and memory course we expect is going to have the kind of things in it that are relevant to the controllers' actions all down through the following years and the SOP project we think establishes ways and means of improving the training base, improving performance, evaluation, and just make the controllers' lives easier all the way around.

Thank you.

MR. PORITZKY: Any questions for Dr. Kinney?

Please identify yourself and state your affiliation.

MR. LEEDMAN: I am Sy Leedman (phonetic), I am with Hazletein Corporation.

Dr. Kinney, could you identify for my reference the document you referred to which you have completed at MITRE on color?

Dr. KINNEY: There is one color document, it is a MITRE technical report and I think it is 7655.

MR. LEEDMAN: Suppose I get in touch with you at your office and ask you for it? We would like to get a copy.

DR. KINNEY: Yes. Well, I have a slight problem. I am limited in the copies so I may not be able to satisfy everybody's request immediately, but I think with the first few I probably can do that.

MR. LEEDMAN: Thank you.

MR. PORITZKY: Any other questions?

MR. KRUPINSKI: Edgar Krupinski, Airline Pilots Association.

Dr. Kinney, I have two questions for you: you said you conducted a system error investigation or information study of some sort and as a result of that you found that the system errors were occurring because of various reasons. As I understand it, controllers forgetting to coordinate or fail to coordinate, they don't listen or they are not hearing what they should hear. I didn't hear you indicate any explanations as to why people do this. Did that come out of the study at all, that is my first question?

DR. KINNEY: They don't do it because they have each developed their own way of doing things and I'm not knocking them, mind you, but there is a little phenomenon in psychology called the "Principle of the Unrecognized Error." What that means is that you can do things wrong for a long period of time before something happens to call it to your attention that it is wrong and it is a natural human tendency on the part of everyone, I think, to do these kinds of things. What we are trying to say with the SOP program is there are ways that are known that people have tried that probably are not wrong and we are going to try to get everybody to do it that way. Is that a reasonable response?

MR. KRUPINSKI: Yes, that leads me to a second --

DR. KINNEY: Everybody will do that, pilots, drivers, you and me.

MR. KRUPINSKI: Right, I agree. That leads me to my second question. You, as a result of that -- if I understood you to say this correctly -- developed for Air Traffic Service something called SOPS which is a standard operating procedure?

DR. KINNEY: Practices, yes.

MR. KRUPINSKI: Practices which are now in the handbooks, I think, for the past two years; has there been any kind of follow-up on your part to find out whether or not the SOPS have, in fact, solved the problem?

DR. KINNEY: No, there has not been anything on our part. There was an evaluation by the 1820 branch. There is a problem of compliance with anything that is new. We know that there are facilities which have adopted the standard operating practices almost completely and they like them and we know that there are other facilities, other controllers which have not yet followed, but we expect that with more time, with more familiarity, with the influx of newly trained people, with the use of SOPS in the on-the-job training and facilities training programs that this will change before too long. We really didn't expect an awful lot to happen in the first year or so.

MR. KRUPINSKI: Thank you.

DR. KINNEY: It is sort of familiar -- it is somewhat similar to the cockpit resource management kind of thing. If you have a large population of pilots and you try to incorporate that type of process it takes time.

MR. PORITZKY: Any further questions?

Yes, sir.

MR. JANSEN: Yes; Leo Jansen of the FAA Tech Center here.

This is just an opinion question on my part, but did you find in any studies that the controllers realize that they are to serve the flying public or are they there to perpetuate their own profession -- I am saying or just asking for an opinion from your experience with them?

DR. KINNEY: Well, I can sure give you an opinion. We didn't study it, most of the controllers we ran into -- well, we encountered or we worked with, were conscientious, serious minded, professionally oriented people. Again, the good things that we think are in the SOP program and in the learning and memory course came from controllers. There are a few who, I am sure, have the attitude that you talked about, but we never encountered it, I wouldn't say, as a prevailing characteristic.

MR. JANSEN: Thank you.

MR. PORITZKY: Homer?

MR. MOUDEN: Homer Mouden, Flight Safety Foundation.

Dr. Kinney, in your comments relative to the impact or potential impact of the use of color and so on we wonder if you can comment and if you feel there is any conflict between the use of this color and the problems that could occur with the controllers and the tremendous effort that is being made both in Europe and in this country by various manufacturers to include color in the cockpit in the displays that the pilots will be using. Some of those that I have seen have also included a significant amount of lower wave lengths in the displays.

DR. KINNEY: Well, that's a loaded question, isn't it, because people are people wherever they go, human eyes are human eyes wherever they go, and you know controllers and pilots are screened and physically examined in about the same kind of process. Indeed they have the same medical in many cases. But, the problems we encounter in Air Traffic Control I am sure would be equally as well encountered in the cockpit. Remember now, this blue phenomenon and red phenomenon I talked to you about, this is a serious problem when you are looking in detail like symbols and that type of thing. If you are looking at something fairly large and fine acuity is not required for recognition or speed of recognition the problems might be considerably different than they would be for the kind of application that we have on the PVD.

MR. MOUDEN: Some of the navigation displays that we have seen and used, many of those for digital displays, for track displays, for projected courses and headings and things like that, we wondered if there is a conflict in research or if there is a failure to adequately research it before it is being used?

DR. KINNEY: I would say probably if I were in your position I would watch it pretty closely because you are going to learn things, I think, through this application that you might not ever have encountered in the research. One of the characteristics of the literature that we find most disappointing is that the experimenter does not adequately define the light stimulus that he was using. He does not give you wave lengths and that is what you must look at. Now, if you can generate a blue without using short wave lengths, then you wouldn't encounter this kind of trouble. If you can generate a red without confining most of the energy to long wave lengths you can probably avoid these types of problems. You still have the color identification problem, however.

Now, in your case, in the cockpit the color is almost totally redundant with the information so you might not have that kind of problem. The kind of thing I was talking about is where you put different colors down and the men are trying to tell just by looking at the color alone what the information is and in the cockpit it is usually redundant. Does that answer the question?

MR. MOUDEN: I wouldn't say that answers it, it does raise questions because I was concerned and probably cannot speak because we are going to have to get into this a little deeper --

DR. KINNEY: Well, I would suggest you try to watch it a little closely and get some data.

MR. MOOR: Don Moor.

This may be a leading question, Glenn, but in order to handle Edgar Pinsky a little better, would you mind enlarging upon the interference phenomenon which you found and we were able to carry to the controller work force that made a great difference in events?

DR. KINNEY: Yes, what he talked about is what I alluded to earlier. Controllers when they sit on a radar position and it is very busy or on a tower position where it is very busy are in an environment where a lot of things are happening. They do not have the control over the sequence at which things are

coming to them. Those things are brought to them by the operational environment. They therefore must be able to shift attention quickly from one thing to another, they must be capable of retaining their awareness of where they were when they left this one so that when they are done they can go back to that one; now that's the interference phenomenon. It happens from dozens and dozens of sources, not all of them are work related, of course, but that's a secondary problem.

In the interference phenomenon the only way we can think of to counteract it is to have well organized, fairly well standardized work habits, carefully worked out phraseology, so that things happen more or less second nature rather than by whatever methods are being used now. There are many ways in which this interference can be cut down and we have already talked about the technical part of it.

Does that answer the question? It's a tough one.

MR. PORITZKY: One more question, one more. Yes, sir?

MR. ROSS: Jon Ross, Los Angeles Tower.

Having sat on many System Error Review Boards in the past, one of the things I have learned is that down the road maybe three or four, six months after the system error has been closed out and final action has been taken, we as controllers learn that there was something involved in the individual's life outside of the facility that may have been a contributing cause at the time. Is MITRE looking at now or are there any plans, can you tell us, that you are going to be looking at the external factors that effect our lives, the morale problems, the family and home problems that we encounter?

DR. KINNEY: Yes, you are citing, of course, some very real problems and we are aware of them. We do not at the present time have any projects/plans for studying those kinds of things. Possibly because right now we have on board the wrong kind of psychologists for that kind of thing; social psychologists, clinical psychologists, would possibly be better for that. However, there is a suspicion that something in the man's home life or possibly something else really maybe ought to be corroborated by looking in more detail at his work habits to see if maybe the potential wasn't there all along anyway and suddenly something went wrong and he missed a thing and it caught. I hope I have conveyed to you and everyone else that I have the highest regard for that

work force. People ask me and say to me, you know about System and you know all about all that other terrible stuff and yet you fly in the airlines? And I say yeah and I better not tell you what flight I'm on. But I do fly the airlines. And, I have an instrument rating, too, so I trust them more than me, frankly.

MR. PORITZKY: Thank you, very much.

We are going to switch gears a little bit now. Those of you who watched the 60 Minutes segment on collision avoidance a few weeks ago, knowing no better, would reach two conclusions, I think. One is that FAA people from management on down are imbeciles and, secondly, that FAA's mind is closed and, to quote the mortal words of Mike Wallace, "That there is a non-invented here complex."

I think you probably have heard enough through the day-to-day from FAA people that the first is not true. The second isn't true, either, but the program did have an appropriate human factors effect on me; it made me furious.

We work very closely with both NASA and the Defense Department and perhaps particularly so with NASA in the human factors area because NASA has a superb resource available to us and to the community. You might be interested that we have across the spectrum some 18 or 20 -- I have forgotten the exact number -- cooperative research and development agreements with NASA covering a broad spectrum of activity, head up display work, cockpit displays of traffic information, activities working flight control systems, and we use the NASA capability to the hilt where we can, and the level of cooperation between FAA and NASA has become superb in the last few years in my view.

Instead of discussing today specific programs like CDTI or HUD or Flight Control Systems, some of which have been discussed in the other work shops, we have asked the NASA people to come to this session to talk about the uses and limitations of the voluntary confidential Aviation Safety Reporting System, ASRS. To tell us about it is the Chief of the Aviation Safety Reporting System of NASA, William Reynard. He is a graduate of Ohio State University College of Law, was admitted to the bar of Ohio and the District of Columbia, he holds a commercial certificate with single and multi-engine instrument ratings, he was formerly with the National Aviation Trades Association, the National Association of Flight Instructors and the AOPA Air Safety Foundation.

He joined NASA in 1976 as counsel to the Aviation Safety Reporting System and assumed the duties of Chief of the ASRS in late 1980.

I am pleased to introduce Bill Reynard.

MR. REYNARD: Good afternoon. I am very pleased to be here; I am always pleased to talk about ASRS.

Before I start I feel compelled to share with you a story that was passed on to me last night that made my flight worthwhile. I want you to picture an airliner, first class section, flight attendant walking down the aisle checking to make sure that the occupants are sufficiently belted in for takeoff. She encounters one of our national sports legends who is known for his larger-than-life ego and she looks at him and she says, "Pardon me sir, would you mind fastening your seat belt?" He says, "Superman don't need no seat belt". She says, "Superman don't need no airplane, buckle up champ" That has nothing to do with human factors, but it seemed like a funny story.

The Aviation Safety Reporting System is designed primarily to gather data from participants in the system which might not be available through any other means. This is not to say that there aren't good systems out there for gathering data, there certainly are. But one of the things we are very good at is getting behind the reason things happen. Somebody five or ten minutes ago asked, were you able to find out why such and such happened? Well, that is essentially what we are looking at. That's the essence of human factors as far as I'm concerned. We very seldom, if ever, accept the label "pilot error" or "controller error." Sure, those persons have erred, but there usually was a reason for it.

In 1975 the FAA initiated the Aviation Safety Reporting program which looked a lot like our ASRS except that the information was fed directly into the FAA. The community felt that the system would be better served if there were a disinterested third party interposed. The FAA came to NASA and said, would you serve in that capacity, and we agreed. So, in April of 1976 we initiated the Aviation Safety Reporting System.

Now, the system itself has four basic elements in its concept. It's voluntary, nobody has to report to ASRS. It is confidential, we are absolutely paranoid about keeping identities away from persons outside the data base, if you will. Within three days after we receive a report you can't tell who it

came from. All the identities have been erased. The success of this has been proven in essentially two ways. Number one, in five years of existence we have never breached anybody's identity even though we have used the reports extensively for research and, being a government agency, we are subject to the Freedom of Information Act, so consequently we have to put up with that, too. But, more importantly, I think we have been able to establish something that was doubted at the beginning of the program. The information has not been misused by anybody outside NASA and, of course, the original thought was, well, the FAA will get a hold of this and they will use it in enforcement actions. That is not the case and that has been proven in two senses: number one, they have never asked for the information in that context and, even if they had, we wouldn't give it to them and they know that and it has been an agreement that is written into a formal agreement for five years and it has worked well. Secondly, in 1979 the FAA established FAR.9157 which essentially said no ASRS data can be used in an enforcement action. Consequently, the confidentiality feature of the ASRS started out as a good idea and if 28,000 reports in five years is any evidence, it has blossomed into a level of credibility that nobody ever expected at the beginning of the program, I think. Thirdly, we are not punitive. You all know NASA has no enforcement mandate, we couldn't nail anybody's hide to the wall if we wanted to. So consequently, our having the information really doesn't do anybody any harm as far as enforcement action. Finally, the major element, I feel of the program, is that it is a before-the-accident program. Can you look at the series of occurrences or incidences and see surrogates for accidents? Can you say because of these twenty occurrences, but for such and such, there was an accident. Then you go back and you accentuate the but-for and you try to eliminate all the enabling factors.

(Whereupon slide presentation was shown.)

So, the four basic characters for the program as the slide shows; the purpose statement is pretty broad, but essentially what it says is we want to identify the deficiencies and discrepancies and we want to provide data for planning. I think we have been able to do that, but not so much in the sense that we had originally thought might be the case.

One of the original contentions, or thoughts, was that this system would be able to dig out pure gold, absolutely unique information; nobody else has this. Well, after five years maybe we are learning something ourselves, but there are

very few unique problems out there. What we are discovering is that we are very, very good at having people tell us the real reason why something happened. There is a lot of difference between writing a report and saying, "This is what happened", and talking to an investigator face-to-face and saying, "This is what happened" versus being able to provide information on a confidential voluntary basis and telling people what happened.

The simplest example I can think of in that regard is the report we got from the pilot who wasn't using the chart he was accustomed to using and shot the approach down to what he thought was the decision marker. After he had done this approach he looked down at the chart and realized he had gone down to the runway elevation. Needless to say he was a believer and the FAA never found out about it and the NTSB fortunately never found out about it, but we did and we were able to contact the chart makers and say, hey, can't you get a little more commonality here as far as this is concerned. Granted, the guy blew it, but as one reporter from the Air Traffic Control System put it very succinctly about two years ago, he said, "This was clearly my fault but I had a lot of help going down the tubes." Then he took 67 pages and told us why. It was a very impressive report. It tends to at least litigate against the argument that a lot of these reports are CYA reports. Some of them are, but a lot of them aren't. One thing you learn in the system is the fact that pilots and controllers to answer again, somebody's question out there -- pilots and controllers really give a damn about safety. There are some CYA and there are some other attributes as to why people do things, but generally speaking the character of the message that comes out of ASRS reports is that these people really give a damn and you can tell that when you read the three or five or sixty-seven page reports as to why somebody blew it.

This is just a brief synopsis of where some of the reports come from. As you can see, it is split pretty much down the middle between the pilots and controllers. There are some variants, but generally speaking it's split pretty evenly. The controllers have about a five or six point advantage at this point as far as the data base percentage of reports. We don't assign probable cause. What we do do is try and attribute a single problem code to a report. If you were to characterize a report by what was the basic problem here this is how it works out in terms of the various aspects of the flight

regime, if you will, of the aviation system. The ATC function, forty percent of their reports dealt with the problem there, forty-one percent dealt with flight crew function, et cetera, and so on down. Again, you see a pretty even split.

The purpose of the program output is to identify certain hazards, certain existing conditions, and to explain why other things happened. We do this in several forms. The program output takes essentially five forms: alert bulletins, quarterly reports, technical reports, what we call special search study reports which less affectionately was referred to as data dumps, and our newsletter. Now, the technical reports I will get into a little later because I have some examples here of reports that deal with human factors and air traffic control. The alert bulletins are our way of notifying primarily the FAA but sometimes the Air Force, the Navy, et cetera, of a situation that may, in fact, be a problem and seems to deserve further investigation. We have no power to go tell anybody to go fix anything. We simply say, it has come to our attention that this condition exists. The criteria, the information of course, in the first place must be credible. If you can't believe the report you sure aren't going to issue an alert bulletin. It has to represent a continuing non-negligible risk. If it's something that's already gone then why report it? Also, it has to be correctable. We are not going to send an alert bulletin on a see and avoid. A see and avoid is a basic concept everybody recognizes as having its pitfalls and really not something that is correctable other than simply by eliminating it.

Some of the examples that we have had of alert bulletins are the following: This one I have thrown in because primarily it has to do with ATC and I am going to read it for you in case you can't see it back there.

"Westfield, Massachusetts, Barnes VORTAC: A pilot reports being cleared from Worcester, Massachusetts to his destination, with Westfield VOR as a departure fix. The pilot could not find Westfield VOR on any navigational charts. A closer look at the charts and subsequent communications with ATC personnel confirmed that the intended fix was the Barnes VORTAC located on the airport at Westfield, Massachusetts. The reported noted that while the terminology problem was a relatively minor one, it was nonetheless confusing and resulted in extra communications and pilot work load." The FAA response was:

"An investigation of the NASA Aviation Safety Report for Westfield, Massachusetts, revealed the incident did occur as reported. A further study of the program indicated that Barnes VORTAC was originally named Westfield VORTAC. Although this does not correct the deficiency, it does reveal a problem associated with changing navaid names. Boston ARTCC, the facility responsible for issuing the clearance, has issued a training bulletin reiterating the correct name as Barnes VORTAC.

We regret the confusion, extra communication, and work load imposed on the pilot because of this error. The Boston Center, the controlling facility, has issued a bulletin to all controllers reiterating the fact that the name of the Westfield VORTAC was recently changed to Barnes VORTAC."

The controller just forgot and called it something when, in fact, it had been changed to something else. The next one is one of my favorites as far as a system-wide indication of a problem.

"Various locations: Recent reports describing encounters between aircraft and skydivers discuss the fact that FAR 105.25 (a)(4) calls for pilots of parachute jump aircraft to report their 'jumpers away' altitude in feet AGL, whereas many controllers and pilots working with IFR flight plans are oriented to MSL altitude references. One report from a pilot who flew directly under a jump aircraft contains the suggestion that this possible AGL versus MSL confusion should be clarified with pilots and controllers in each instance if any misunderstanding may exist."

The first response from FAA was:

"We have established a project to study the recommendations contained in NASA Alert Bulletin 78:54."

What brought this on was a series of reports from controllers saying they had problems with jump aircraft and skydivers in relationship to the general flow of events. Finally, we got a report from a pilot who was flying over the eastern United States and had been told that he had air traffic twelve o'clock five miles but it was reported three thousand feet and he, in fact, was at four thousand feet MSL, so it didn't seem to be a problem. The problem was that the jumper craft was reporting three thousand feet AGL over about a three thousand foot terrain. That put him at six thousand feet. The next thing this pilot of the air carrier aircraft knew he was surrounded by these blossoming

parachutes and it didn't please very many people at all including the skydivers. So consequently, the report was sent forward and an investigation revealed that there was, in fact, a problem. Since that time FAR IFR have been changed to indicate the jump aircraft will report their altitude MSL and the advisory circulatory agency to skydiving has been clarified to point that out also. This is an example as to what this type of information can yield if you are able, number one to get the information, and, number two, to track it.

We retain ASRS reports in our computer through our contractor Battelle & Morgan Institute in Columbus where they have a field team working with us and the basic computer is in Columbus and the reports are maintained in that computer in an analyzed form and the data base itself is broken down into three general categories, if you will: We have the fixed field, the diagnosis and the free text. The fixed field are the specific questions we have asked the reporter, "What was your altitude?", "What was the time of day?", "What was the wind condition?", and so on or the weather condition and so on, et cetera. There are numerous categories there that are specific items that don't have a whole lot of variance. The term fixed field is really a very good description of it. The diagnostics are the products of the people the contractor employs who are reading the reports and saying, "All right, there is what we see in this report and here is what the reporter is saying."

One of the decisions we made early on was that our researchers would be people who are accustomed to aviation. We had to make a decision; do we want researchers and train them in aviation or do we want people who know aviation and train them to research? We decided that the best course of action was to get aviators and train them to research. So, consequently, all of our people are duly qualified in a very general sense in that they all are primarily what a program manager refers to as his "grey beards". They are retired people who have either been air carrier pilots, air traffic controllers, G.A. pilots and in the sense of corporate operators. In one case we have a G.A. pilot who is an inspector, a retired GATO Inspector. So, these people know what they are looking at. This is beneficial both from the standpoint of the diagnosis and also from the standpoint that we have a feature called "call back". If we want to find out more information within the first few days that we have a report we can call the reporter back and ask him a question, "What was the weather like?", "Were you having any kind of personal relationship problem with the

guy sitting at your right side?", "Was there a sense of antagonism between you and the controller", hence we can fill in these blanks if we feel it is important. That all goes into a diagnosis. Finally, we have the free text. We made the decision, again early on, even though it was going to cost us some money, to keep the narrative that the reporter sends to us in the data base because there is a flavor there that doesn't exist anywhere else. You can do all the fixed feeling and all the diagnosis you want, but it's the guy who was in the situation who had the problem who can tell you the best story. So, we have kept that.

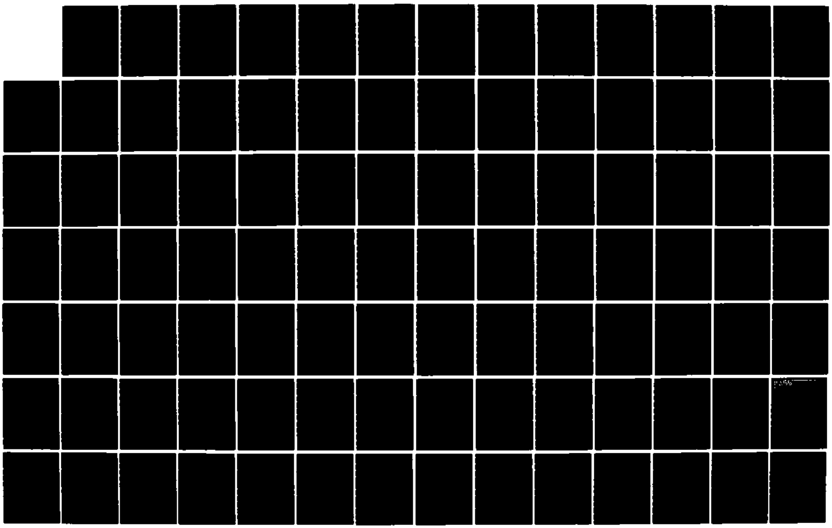
Some of the examples of research that we have done in the past are enumerated up here. I want to read to you from a more recent one just to illustrate this specific problem; how we can take a look at the problems within the ATC system, the aviation system generally but the ATC System specifically and they do some research. This is from a monograph that is coming up for publication -- in fact, it's in publication stages right now -- on information transfer. It's the product of a lot of research done by several researchers, but I am going to read to you from the summary that was done by Dr. Billings and Ed Cheaney, our Battelle Program manager, which essentially sums up the findings. Now, I believe that this particular report in its totality is going to be included as an element of the proceedings here. If it is not and if anybody is interested, you are certainly welcome to contact me and I will be happy to send a copy to you when it's printed. This is preceded by six chapters, the concluding one reads as follows:

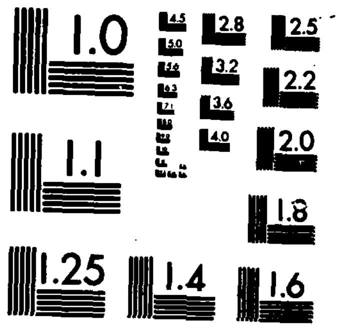
"In this concluding chapter we broaden our focus of consideration from the specifics of the foregoing chapters to the aviation system as a whole and the information transfer problems that are found in it. An attempt is made to characterize these problems independent of the settings in which they occur and in so doing to suggest possible intervention strategies for the consideration by the designers, managers, and operators in the National Aviation System. Information transfer problems are perceived by experienced analysts to exist in the substantial majority of all the reports submitted to the Avation Safety Reporting System. The absolute incidence of such problems cannot be deduced from these data, but during the period of study, May '78 to July '80, on an average over 4,8000 such problems were reported per year. Now, we receive about 5,500 reports per year so you can see that that thread of information

transfer problems runs through a vast majority of them. Over one third of these problems involve the absence of information transfer and situations in which, in the opinion of the analyst, the transfer of the information could have prevented a potentially hazardous occurrence. In another third information transfer took place but it was adjudged incomplete or inaccurate leading in many cases to incorrect actions in flying or controlling aircraft. One eighth of the reports involved information transfer that was correct but untimely, usually too late to be of assistance in forestalling a potentially hazardous chain of events. In one tenth of the reports the information was transferred but not perceived or was misperceived by its intended recipient.

The remainder of the reports involved equipment problems in a variety of miscellaneous and specific conditions. It is concluded that these data give evidence of deficiencies of operational importance in the National Aviation System and that these deficiencies can cause or contribute to the specific hazards to the safety of flight. Most of these studies was not primarily upon whether or not information transfer problems exist, but upon the factors that appear to be responsible for their existence. It is not possible from retrospective data to state whether such factors cause such problems under examination, but it is possible to state with confidence that certain factors are frequently found in association with information transfer problems and that they may be causative. Several facets of the information transfer phenomenon were examined in an effort to find factors in common. Such common factors were, in fact, observed. The human behavioral attributes found frequently in association with information transfer problems and rough order of frequency were a distraction both in the cockpit and in the air traffic control facility. Forgetting, both on the parts of pilots and controllers, failure to monitor -- nobody is home -- non-standard or ad hoc procedures or phraseology, finding complacency, these attributes where present were associated with failures at all points in the information transfer chain. In addition to each human factor, certain system factors were also found and reputed to be associated with information transfer failures. These factors included: Nonavailability of traffic information, degraded information, ambiguous or rarely absent procedural guidance, environmental factors such as noise and confusion, high work load and equipment failure. The first three of these, of course, are within themselves information transfer problems. The fourth, environmental factors, was associated with difficulty in performing the required tasks. The

AD-A150 459 HUMAN FACTORS WORKSHOP ON AVIATION (4TH) TRANSCRIPT 2/3
HELD AT ATLANTIC CITY..(U) FEDERAL AVIATION
ADMINISTRATION WASHINGTON DC OFFICE OF AVIAT.. MAY 82
UNCLASSIFIED FAA-ASF-81-9 DOT-TSC-FAA-81-22 F/G 5/5 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

fifth, high work load, was associated with task demands that could not be met by the worker. The last, equipment failure, though present in significant amounts was the least frequent system failure reported. Many other factors were observed in specific context. They are discussed in the preceding chapters. These factors, however, appear to be of general importance. Possible reasons for this are set forth in the remainder of this chapter."

And then it goes on to talk about the information transfer problems affecting the controller, the failure to perceive, misperception of information, the controller role in the genesis of information transfer problems in that he doesn't transfer the problem or the information at all or the transfer is untimely or it is incomplete or it's inaccurate, the role of the pilot in the sense of the information transfer problem in that -- well, let me just read this briefly:

"The role of the pilot in receiving ATC services and information management is somewhat different than that of the controller in the present aviation system. His task, excepting an emergency, is normally to receive advisory information, accept instructions and to act upon them. He provides an element of redundancy by reading back clearances, announcing altitude on an initial call-up, et cetera, but otherwise provides little information unless it is asked for, as opposed to the controller who is a rather significant conduit of information."

The study addressed also the rule of automation:

"Studies by ASRS investigators and others have made it clear that automation, whether in the cockpit or in the ATC, is associated with cost as well as benefits with respect to human performance. ASRS reports describe a spectrum of behaviors from unwarranted suspicion to overreliance upon automated devices."

As you all know, the more you get the dongs, the bells, and the little devices, the little pictures, the more you come to rely upon them and when they don't work you're really down the tube.

This particular study is but one of the studies that we have looked at that have tried to deal with human factors in air traffic control. Some of the others we have already published and are available if you are interested. They also provide good examples of what the system is capable of doing both in terms of its own research, but, more importantly, -- and this is what we

are finding out to be a growing trend -- using ASRS data to supplement other well established and reliable systems of information. Some of the examples of the research that we have done that address the issue of human factors considerations and air traffic control operations:

1. Misunderstanding Of Communications Between Pilots And Controllers. This appeared in our quarterly report number three, May of 1977. It essentially talked about the broad scope. It was an overview, "What can go wrong?", "What are the things that happen?".

2. Human Factors Associated With Runway Incursions. "Why do these things occur?" This arose because of the unfortunate circumstance up in La Guardia about three years ago where a Cessna Citation heading east on the runway encountered a DC-9 heading west on the same runway. Following a very skillful half gainer on the part of the Citation, when the dust settled nobody was necessarily hurt but the big question arose, "How often does this type of thing happen?" So, we took a look at our data base and found it happened quite a bit and it happens because of the very reasons we have just cited here in this information transfer problem; forgetting, complacency, hearing what you want to hear, et cetera.

3. Human Factors In Air Carrier Operations: Knowledge of the limitations of the ATC system in conflict avoidance capabilities. That appeared in our quarterly report number ten of April 1980. It's amazing how many pilots out there don't know what the ATC System isn't capable of. There is a large reliance as the system becomes more capable of handling the type of traffic it is handling, as it becomes more competent in its ability to do what it is designed to do, there is a larger and larger reliance placed upon the system. Sometimes there is an overreliance. Consequently, you get the confusion -- for instance -- about what controllers really can tell you about the weather, what controllers really can tell you about traffic, what their obligations are in regard to pointing out traffic, et cetera.

In Q.R. Number 12, the quarterly report number twelve soon to be published, there is a report on the Problems In Briefing of Relief By Air Traffic Controllers; the problem being the assumption factor. Well, it's there, I assume you see it. The forgetting factor or, "I forgot to tell you about this guy", so on and so forth.

Finally, there is one that is more oriented towards pilots but it has an implication with regard to Air Traffic Controllers. That one is also in Q.R. Number 12, quarterly report number twelve. It is Altimeter Reading And Setting Errors As Factors In Aviation Safety. The Air Transport Association asked us to take a look at the data base and tell them how often do we see problems of altimeters being misread. Of course, the big bugaboo there is the three pointer altimeter. What we found was that there are many instances of altimeters being misread but, more importantly, there are a lot more instances of altimeters being missed and this is the problem primarily of the cockpit crew, but it is also shared somewhat by Air Traffic Control when they give them the wrong information or the presumption is there that they know the setting because the controller must have given it to them before, et cetera.

Finally, there are three publications on their way out right now. They are still in the review stage: The full text of the information transfer problems that I read you the summary from earlier. Another one that is just being -- or has just been assigned to contract a report number, The Potential Effects Of The Introduction Of the Discrete Address Beacon System Data Link On Air/Ground Information Transfer Problems. That's the data link. What does our information show the possible effects might be if this were in effect? Or, finding out that generally speaking it is a very positive move which you also have to recognize, that there are things that you have to give up. One of the things you give up is affectionately referred to as the "party line". How often if you are a pilot, or have been in the cockpit environment, have you heard something that has alerted you to the fact that maybe you ought to be aware of something else happening? A classic example is when you hear traffic being vectored and it is the same altitude you are and you know you are basically at the same geographical location and a light goes off and says, "Hey wait a minute." I know that wasn't meant for me, but he is awfully close to me. So consequently, you have got that characteristic. You have got a factor in there as far as its law in the DABS Data Link role of things. Conversely, in the very same vein you have the number of times when people have picked up the wrong clearance because it was aimed at somebody else, because of the party line. This is what this study addresses in addition to many other issues.

Finally, a draft report which is really a draft report at this time, it doesn't even have a CR number: ATC Contingency Operations In The En Route Flight Regime. Taking a look at ASRS flight reports and finding out what do controllers do when they have to go into a contingency mode in the en route environment? Consequently, there are eight examples of the way the data base can be used for human factors and ATC type operations and, of course, that doesn't even incorporate the things we have looked at as far as the cockpit regime and procedures, et cetera.

I guess my message is that it is a useful system. I feel very flattered to be a part of the system simply because as a lawyer I got there quite "in through the back door." But the fact remains that it is a good system, it has value, we can get into somebody's mind on a voluntary basis. We can't get there unless they want us to be there, but in the five years we have received 28,000 reports and that's indicative to us that the controller community, the pilot community and just a whole bunch of other people out there are really concerned about the situation and as long as they know that they can contribute in relative confidence, and that the information will be used beneficially they will tell us, and as that data base grows it is going to be more and more useful to us, to the FAA and to the community as they see fit to take advantage of it.

Thank you.

MR. PORITZKY: We are running a little short of time. Let's take a question or two if there are any. Any comments, questions?

Ed Kurpinsky.

MR. KRUPINSKI: Thanks, I would be remiss if I didn't express some comment to Mr. Reynard on the part of ALPA for the work the ASRS people have done. More recently we requested some information from them on the problems associated with visual approaches and he sent us a report which was about three quarters of an inch thick and, as a matter of fact, it helped the people in the Inner Traffic Procedures Advisory Committee to come up with some very strong recommendations to the FAA on that subject. So, I want to thank you personally.

MR. REYNARD: You're welcome. I would like to point out if I may that one of the things we are limited by, of course, as with any unit, is staffing and funding. So consequently, when I say to you that the information is there to be used, I want to point out to you that we very seldomly do research in the

sense of really getting in and actually digging for anybody else except the FAA and NASA simply because it takes a lot of money and staff time. But in terms of the availability of the data, if you ever have any questions about what we have got or how you might be able to use it and the availability of that information, my number is 415-965-6467. Call me, we will talk.

MR. PORITZKY: Let's go on now to the final presentation in this section. I mentioned to you earlier that we have worked closely with both NASA and the Defense Department. Most of you know that we have military officers in a number of places in the FAA who work with us day-to-day. You may not know that we also have military officers whose primary responsibility is to be sure that we are aware in FAA of research and development activities of DOD and vice versa. These poeple frequently make possible interagency agreements for our joint activities with DOD. The final paper this session before a brief coffee break -- and we are a little behind schedule -- is a presentation on mission management in the future ATC System which will be given to you by William Young from the Air Force Flight Development Laboratory at Wright-Patterson Air Force Base.

Mr. Young began work with the Air Force in 1970 as a flight control engineer first assigned to helicopter stability orientation system development and flight test. Later work included real timing work on board Trajectory generation and tracking in a highly automated environment. Mr. Young is currently involved in technical flight management programs aimed at providing the capability to fighter aircraft to operate in a hostile low-level environment under all weather conditions. This program addresses all levels of automation in the aircraft and operating in an arena where close control would be maintained via data link information.

Mr. Young.

MR. YOUNG: Those of you familiar with Air Force 3510 probably realize that I am not an officer. As it says in the program, I am from the Air Force Flight Department Laboratory. That's not true, I am from the Air Force Wright Aeronautical Laboratory.

In my presentation today, I will discuss briefly the stated Air Force needs, the implications and concerns forced upon the mission management system and on the man/machine interface and the work that we in the Air Force Wright Aeronautical Laboratory are working towards those needs and concerns. The Air Force,

as stated by the Department of Defense, to be able to operate we must be able to operate in night, low visibility conditions, be able to maintain accurate time, space positioning, and, when it is available, to operate in a very complex command and control environment to maximize losses to the enemy and survivability to ourselves. A lot of the times we do this with a single seat cockpit flying very low to the ground. You know what we are talking about is less than two hundred feet altitude at speeds in excess of four hundred knots. Things happen pretty quickly, targets are moving quite rapidly on the ground, so the work load can get very high. Obviously the work at AFWAL is highly influenced by the PATCO Theatre. The capabilities we are trying to provide, of course, are ones to meet the Air Force needs. Fortunately most of the time we are operating in friendly environments, we are mixing with the airliners and the civil aviation aircraft, so we must maintain the capability to satisfy the performance requirements of the National Air Space System. Of course, you know, we want to fulfill both of these needs and we don't want to end up with a cockpit that ends up looking like this (indicating), although some of our cockpits have hundreds, literally hundreds of switches.

(Whereupon a slide presentation was shown.)

Single aircraft flight control technology looks a lot like this (indicating). The aircraft is commanded -- or I should say that from the air traffic control he is instructed -- to maintain headings or instructed to make descents. Of course, the pilot is the one that has the last say in the whole thing, but we all tend to try to work together.

To perform this mission, whether it be in a tactical environment, or whether it be in the National Air Space System that those instructions are given, the pilot must somehow interpret those commands. He must either make control inputs into the airplane or talk to a computer through the keyboard, cursory control, whatever. Then he hears their surveillance system, whether it be radar, whether he reports back what he is doing. As you will notice, the thing we are looking at is how this pilot fits into the middle of this thing. He has to take the information, convey it to the airplane and have the information coming back in such a manner that he can interpret it and he can do the right thing. Of course, there is a lot of concern when you start talking about operating in today's environment. There is the concern over conversion through the sample data system, what data it needs to be entered into the system, in how many rates. If it's

primary flight control confirmation it might have to go in at a much higher rate than traffic information due to traffic doesn't just move all that much or due to the tactical environment, the target information. Some targets tend to move, some such as dams, power stations, do not tend to move. This is one of the points where we tend to sit in with the ATC, in that the Air Force, you know we have threats that we have to go around. Whether it be high concentration of enemy troops, whether it be surface-to-air missles, that we have to go around. In the case of the National Air Space it might be thunderstorms, it might be a high density population that we need to go around or other traffic. The same thing with slot time. In order to increase our survivability we will want to go in with an aircraft which enemy radars can't pick up. If he moves he has to stay within his protection very precisely so that we don't get blown out of the air.

It's the same thing with slot times when you start talking about the metering space within the control system and those common elements.

Our command and control data link is referred to as J/TIDS. Probably a lot of you are familiar with it, it's Joint Tactical Information Distribution Systems. Since this thing came up, we were concerned that a lot of people were just going to send up steering information, just put it on the HUD and all the pilot had to do was sit there and follow a little needle. But, we were very concerned that since you have got to put a pilot up there and he needs to make the final decision, that information must be sent to him in such a way that he can look at it, and he can interpret it, and determine whether his airplane is capable of meeting what he has been asked to do, and be able to tell his airplane to do that and so forth.

To sort out these problems and concerns, our concept has been toward a functional integration of historically separate systems such as navigation systems which our Avionics laboratory has worked on through the years, and our flight control system which we at flight control at the flight laboratory have done. You figure if we add these all together with the new digital systems it would make it a lot smoother operation and we would be able to perform the trajectory generation and tracking and we would be able to consider the vehicle within the total mission as well as the constraints to the vehicle, one of which is fuel flow, fuel quantity on board, et cetera.

As the integration of the aircraft systems evolves, the role of the crew changes. He now has so much more information and so many more systems available to him than he had in the past. When the crew's role starts changing, so does the cockpit. Now you can't have a bit of information over here and a bit of information over there and have the pilot able to look at it. He has so much information and we have so much more capability to process that information and display it to him in a manner that he is able to view it and to make decisions concerning the tactical environment. It's the same with the National Air Space. You could look at his traffic and decide what the best way is for him to do it.

The integration problems facing us to date are: The equipment is developed separately and without a thorough integration concept. I think this is obvious to anyone who has worked in the business, you know. You have people developing one thing over here and other people developing other concepts over there and when it comes time to put it all together they are not necessarily what they could have been if the people had worked together a lot more closely in the first place. So then you have to come up with an interface box to make it all work together. All this results in a less than optimal interface. You have poor man/machine interaction, this increases the pilot work load, of course, and can contribute to errors in situations that require fast thinking. Poor displays, you know if each system has its own display then the pilot may have to get a bit of information that he needs from a segment over here, a bit of information from another source over there and put it all together in his mind before he can come up with what the best thing to do is. You start looking at some of the programs that bring the required information for the mission segment into a central display, and with the modern display you can change formats, bring in quite different information depending on whether you are in a weapon delivery mode, a landing mode, a takeoff mode, a refueling mode, whatever. Worst of all, however, our growth potential is very poor. This is mainly because the fighters -- I will use fighters -- fighters are very small airplanes and when they are built they are just pared down to the very least that they can get away with. So, when something new comes along it may be the greatest thing since round tires, but the fact that there is no growth potential built into the airplane in the first place, a lot of these great new things end up as reports on engineers' desks and not something in the airplanes that our pilots can use.

A real noble goal here would be to strive for such commonality as this, where we could have the same type displays in the same locations. We could buy twice as many displays and get breaks in the price. The training - you could train all our pilots in basic flight training in the same airplanes and everything, so you would cut the cost in equipment as well as in the training time.

This is one of our airplanes that we are using for our flight tests. It is presently being used at AFWAL to evaluate and demonstrate flight management concepts. It is also used to look at wind shear effects and creative actions of how before you actually get into a real serious situation it gives you the corrective actions to get out of the problem before it occurs in the first place. This is a joint program, an FAA and USAF program. At this time there are other programs being contemplated using this airplane.

We decided that since the fighter had basically one seat in it that it was going to be run by one man. He probably has the most demanding task of all, so we decided to try to help his problem in that we could transition information upward much better than we could transition it downward into the fighter. This program was conducted in a fighter simulator toward a fighter mission and we demonstrated it, or we refer to it as the 4-D trajectory generation/tracking logarithm program. We use that in combination with command information displays and we evaluated the autonomous and also how does the pilot operate in the C-squared environement, that is the command and control environment. It is one thing to send up information to a pilot that he can read on display that says for him to go to a certain location, pick out a bridge and blow it up much like you would divert a pilot to another airport. Although he could read in his approach chart and it is a little simpler than flying over terrain he has never seen before, picking up a target he has never seen before and conducting, for lack of a better word, very hairy maneuvers to destroy that target. We found that there are ways that one can put that information into the on-board computers and that can be crunched in, -- excuse me for using that word, -- crunched in with the other available information of fuel on board, speed of the airplane, and he would then be given options in a much bigger picture than Lat, Long, Altitude, so he would be able to make a much more efficient oriented decision.

This is an example of the messages that were first sent to us by the Tactical Air Command and they apply to the F-16 fighter. You can see that the pilot is flying along and he gets information such as new threats that come up, you know, where are other airplanes both friendly and unfriendly, the weather information, rendezvous data, maybe tankers get changed, does he have enough fuel to continue with his mission as previously stated and still make the new tanker assignment. This type of information is what they are going to have to put up with in the new C-squared environment.

When J/TIDS first surfaced, displays such as this were proposed. Much studying was done as to how you could come up with a symbol so that when the pilot looks down he could tell if it is a good guy or a bad guy, an I-don't-give-a-darn guy. And we did a lot with well, maybe colors would help, we put a red color, a green color and amber color and so he could look down at it and if it looked like where he was going was all red then maybe that wouldn't be a good place to go. So -- but again, you know, it's something that is very simple. As we are standing here you could probably draw a line through there and come up with a real safe way to come through it. The problem is the pilot may be getting shot at by one of those little red things while he is trying to figure out the best way to go. It would be just as easy if you knew what each one of those were, if they were surface targets, he knew the lethal range of all of those weapons and everything, those could be put into a computer. That could be then taken into account of where your airplane is versus where your airplane wants to go and the computer could go through and figure out your most survivable path. Now, that's not to say the pilot would have to take that, but, at least he would stand a good chance of knowing where it is. So, we feel that this is just one way that we can help the pilots in the high density tactical theory.

This is the cockpit we used in our strike element demonstration. It is no cockpit out of any airplane, it just happens to be the same dimensions of the F-16 because it's the smallest one we have now. So we figured we'd start out with the smallest one and see what we could do for that fellow. The display in the center, the lower center, is what we call our tactical situation display. It shows the profile that the pilot is going to fly and the round circles are the surface air threats. There are no aircraft threats on there now, but we try to stick with the standard symbology that was developed in previous studies.

We feel that the future systems must contain the attributes listed here to meet the Air Force Requirements and also to be able to perform within the National Air Space System. It is just that the systems must be flexible, the pilots must be kept aware of what is going on. We are going to be working in a data link environment and we just must be very careful as to how we put that information into the cockpit in order for the pilot to use it. In the beginning of our studies we found that if the information just went in and was listed on a display, if he was doing a lot of other things he really didn't have the time to pick that information off and enter it into his computer with a lot of keypunching. However, if we did put it in, in the form of a trajectory where he could look down, make it assessable and then just enter the information -- all you had to do was enter it -- sometimes he would have to modify it but usually the modification was far less demanding than putting in the whole profile changes in the first place.

In summary we feel there are some issues that are still unresloved. The levels of automation, how automatic can we make the whole thing? If you made it to the point where you just punched a button and you could take off, land, and not have to worry about it -- very expensive. The redundancy levels would have to be enormous. How do we handle the functional integration of the ground and the airborne? This is like when we have missiles on airplanes. You can make missiles super smart and airplanes super dumb and you send a missile off and it kills the target you sent it out to in the first place. It's the same thing here. If we put all the smarts on the ground we would have a very enormous system and the airplanes would just have a very simple flight control system and vice versa. If the airplanes were extremely smart then all we would need is someone on the ground to tell them where to go and what time to get there. So, I think there is a lot of work to be done so that we come up with the best mix. We need to work with the controllers, the people who have to do this day after day, and we have to work with the pilots because they also have to operate and we have to have the acceptance by the pilots and the controllers to make this system really work.

MR. PORITZKY: Any questions or comments?

MR. PARSON: Mac Parsons, from Humro Office.

In amplification of what Mr. Young said I think it may be useful for you all to know that the ground systems for the CG C-squared for the C-squared ground systems for tactical air command and its operations are being developed at the Electronic Systems Division of Systems Command (ESD) at Hanscom Field in Massachusetts. It is the airborne systems that are being developed at Wright Aeronautical Laboratory. Another point in that connection is that there are many parallels between what is happening in the automation of air traffic control with the FAA and the automation of the Tactical Air Control Systems by Electronic Systems Division. Third, there are substantial research human factors programs being undertaken in support of the ESD Tactical Air Systems that are being automated and these are in the human resources laboratory at Wright Field and in the Aeronautic Research Laboratories at Wright Field.

MR. PORITZKY: Thank you; any other questions?

Thank you very much.

You think you are going to get a coffee break now, but you are not. Once again, there are one or two things that you have to do. Young ladies and gentlemen, I think, are going around passing out pieces of paper for you. Those pieces of paper are intended for you to fill out the particular work shop that you will be planning to attend tomorrow at the Technical Center. If you will take one of those sheets of paper as they are handed out to you and then deposit them at the desk outside, the Technical Center people will be able to make the physical arrangement at the Technical Center for tomorrow.

We are running a few minutes behind schedule and I notice that some of you have snuck out and had coffee. It is now 3:30 and we would like to resume at 3:40 because the Brighton Hotel would like you to have time free later.

(Where upon a short break was taken.)

MR. PORITZKY: Would you take your seats, please.

We now come to the part of the session, the first session, in which we will hear definitively from the user organizations, the participant organizations who will, I hope, give us their perceptions, recommendations, ideas on issues we have been discussing. I have at the moment four organizations who will be making presentations. I asked this morning if any of you wish to make extended presentations and wish to have them scheduled to let me know. We would be delighted to arrange it; ovbiously you will be offered the opportunity to speak

informally. We have not had any other organizations or people who have indicated a desire to speak including the fact that none of the people in the accademic or consultant community have bitten on my challenge to offer us their wisdom on a couple of issues which I mentioned this morning. The floor will still be available to you and we will hope you will take me up on it.

We will hear first from the Aircraft Owners and Pilots Association and we will hear from Bob Warner who is Vice President for ATC Airports and Air Space. I think most of you know Bob Warner.

Bob, the floor is yours.

MR. WARNER: Thank you. Why couldn't we put the podium up front, I would really feel like I was in show business if I could be on the stage. The only thing more exciting than that is getting to talk before ATA for a change.

I have been going to meetings for AOPA for eleven years and as far as I am concerned this type of a meeting, this subject, is at least that many years overdue.

There has got to be something basically wrong, and the subject of human factors in air traffic control needs to be addressed when such events take place as an airline pilot, a line airline pilot that participated with me during the midair collision investigation in San Diego, was surprised when he found out that he was not separated from everybody just because he was on an IFR flight plan, and a private pilot who was involved in a midair collision in the Daytona Beach traffic pattern was surprised when he found out that the controllers don't separate airplanes in the airport traffic area. Unfortunately, I have flown with a number of pilots that look out the window whenever a traffic advisory is given to them and that's the only time they look out the window. Many pilots have said to me since February when we were involved in a midair collision investigation at Fort Lauderdale that they would have done the exact same thing that the pilot had done in that aircraft -- they would have flown down the center line of the runway. I have also had controllers tell me that if a pilot declines "Stage III" radar services at departure, that they wouldn't provide him with Stage I service, they wouldn't give him any traffic advisories. The book tells the controller that he will, but many controllers have told me that they would not.

I am not a psychologist, I am just a pilot, an accident investigator and a student of air traffic control as many of you that are not actively involved in air traffic control are. I feel that I do have the position to be able to beat up on anyone that I want to on the subject of air traffic control and human factors. I fly one hundred to two hundred fifty hours a year. In the last year I've flown my single engine plane into JFK and into the grass strip at Cascade, Idaho. I've flown with bush pilots through the mountain ranges of the west, and I have flown in airline cockpits, the airline to be unnamed. As to my qualifications in dealing with the FAA, I have been a member of the Air Traffic Procedures Advisory Committee since its inception, so that's either my honor or punishment that depends on the day and the subject at hand. So, if anyone feels like I am beating up on them in particular, be they airplane pilots, controllers, general aviation pilots, or the FAA, it is all with the best of intentions.

I am not here on an AOPA crusade. In fact, I don't particularly have any recommendations this afternoon. However, I thought it would be helpful to maybe paint a little bit of psychological picture of a pilot and controller and get us all thinking about the specifics of the system that we might be discussing tomorrow.

Let's take the controller first since they tell the pilots where to go. The controller, as we all know, is the ultimate macho man but we are not quite sure who we are supposed to believe as to how much stress and anxiety there is in his job. If we believe the popular press and perhaps even to a small degree if we believe the controller union, they'd show us a person who has thousands of thousands of lives in one hand and a cup of coffee in the other hand. Or maybe we should believe an FAA study which was concluded in September of 1980. It was a report of a decade of research on air traffic control stress and anxiety on the controller. It stated: "Air traffic control specialists are well within normal limits on every indicator of psychological states used in the studies and appear to experience less anxiety than is the average in other work settings."

Controllers are the great intimidators, particularly of general aviation pilots. You don't have to spend much time monitoring the frequency to find that out. Of course, we are very familiar and through our discussions this morning already we know of many controller problems which add to their human

factors difficulties and failures to coordinate hand-off, noncompliance with letters of agreement, problems with equipment, possible influence of the union, that sort of thing.

Now to paint a brief picture of the pilot. Don't be quick to divide the airline pilot from the general aviation pilot. They both have a large ego as do controllers. They are both the psychological animal that must be addressed. While the controller is holding the lives of thousands in one hand we have all come to know that pilots hold airplanes up in the air with their bare hands. Jimmy Stewart shows us how to do that. Of course, there may be some extra-curricular activities which are going on besides flying the aircraft that may have an influence on the pilot's well-being, his psychological well-being. For the airline pilot that may be that while he is monitoring the complex systems of the aircraft he might be considering what is going on at home or the financial well being of the airline that he works for. For the general aviation pilot it might be something really simple like just trying to keep the airplane upright while his wife is throwing up next to him and the kids are wetting their pants in the back seat. These have an effect on the performance of a pilot for some reason. Often times, the division between the air carrier pilot and the general aviation pilot is a matter of perception or the flying public's perception. Of course, the air carrier pilot is a smooth professional in every way. He portrays an image of that professionalism. He does that while he flies the airplane into water or into the mountains or off the end of the runway. General aviation pilots, of course, in the public perception, we know what they are. They come unglued at any small amount of uncertainty, they are anxious, high strung, nonprofessionals, and there is a great question that they might be a little bit short in the sanity department.

I don't mean to be pointing fingers, but all of these factors and situations point out the need for study of the psychological composition and environment of air traffic control. Richard Jensen, a professor at Ohio State University, has done extensive studies on pilot judgement. He states that every pilot decision -- air carrier, general aviation pilot, military pilot -- "is colored by psychological, physiological and social pressures that are virtually impossible to weigh properly on the spot."

In NASA's tenth quarterly report that Bill Reynard mentioned earlier of the ASRS there was a discussion of human factors in air carrier operations concerning their knowledge on air carrier pilot's knowledge of the air traffic

control system. That study states that there is reluctance of pilots to confirm instructions and confusing clearances. We know for a fact pilots have sat in the cockpit and discussed their misunderstanding of an instruction or a clearance as they fly the airplane into the ground. We know that pilots have a tendency to hear what they want to hear and to do what they -- what often times is their habit. In 1978 the NASA study said there were seven hundred ATC alerts and requests for assistance for priority handling by air traffic control. Seven hundred requests, five hundred seventeen of them came from the military. There are more air carrier, general aviation pilots than there are military people flying and that certainly brings us to a logical conclusion that there must be something that is keeping those general aviation and airline pilots from asking for assistance.

Let me beat up on the FAA for a while. The FARS are not sought out from the human factors standpoint period. Just one quick example. The FAR says that if you're cleared from the ramp to taxi to the runway for takeoff you are not cleared to cross the active runway but after you land when you clear to the ramp you are allowed to cross anything. That doesn't make much sense. And how about the procedures? How do I know when there is a BRITE display in the tower cab or not? If there is one, how do I know whether the controller is radar-qualified or not? Is he permitted to give me radar vectors or just advisories? What is the difference? The automatic termination of radar service completely ignores the human factors. Procedures, but to a much larger extent the FARS, are heavily influenced by the General Counsel's Office. In my opinion, those folks aren't the least bit interested in human factors and they have helped put us where we are today.

Now, let's discuss a few situations that exist in the air traffic control system today. The NASA report comes to many conclusions and Bill touched on this briefly, I would like to quote it: "Routine expectation of radar surveillance often apparently produces an exaggerated dependency on controller intervention." Let me read that again: "Routine expectation of radar surveillance often apparently produces an exaggerated dependency on controller intervention." I don't think I need to say more.

There are strong indications that pilots on visual approaches still think they are being provided with radar service and that includes separation and sequences and traffic advisories. It is also reason to believe that air

carrier pilots think that the ATC system will keep them in the TCA which is their responsibility under the FARS.

Pilots think that they are getting separation when they are in the airport traffic area. They think that they are getting traffic advisories for everything when they are in radar contact particularly if they are on an IFR flight plan. Those of us that know the book, know that isn't the case. Where do they get these ideas? Where do these pilots get these ideas be they general aviation or air carrier pilots? Of course, the FAA says if they read the AIM they wouldn't have these problems. But, I'll tell you where they get them. Pilots are common sense people. They are human beings and they are affected by human factors, by habit, by exposure, and by education. Go up to any freshly rated private pilot and ask him the question: Why else would anybody require you -- why would the FAR require you -- to contact the tower within three thousand feet, five miles of the airport if some wise person or institution hadn't decided that they were going to keep planes from running into each other? That's the answer you're going to hear from that pilot. Where else did they get the information? As an aside, last night I was in Buffalo and spoke at an informal air space meeting on a proposed air terminal control area for Buffalo. There were about eight hundred pilots in the room and I won't mention any names, but there was an FAA designated pilot examiner of 29 years, very well known in the area, tens of thousands of flight hours, who made the point during his comments that when you are leaving a terminal radar service area you shouldn't be getting anything and then that he had a battle over the radio recently with a controller where the controller told him that the Stage III service was mandatory unless he declined it and this pilot examiner of 29 years said, "I know that's incorrect". And, the FAA Branch Manager from the region who was standing at the podium agreed with him and that was in front of between 800 and a 1,000 pilots. How many of them are going to go back and tell other people that incorrect information? How many of them are flight instructors who are going to teach that wrong information?

New actions and regulations by the FAA are not making matters any better. Take the case of an increasing number of Terminal Control Areas. The regulators don't take into account the human element of the increasing amount of the terminal air space in which positive control is required. As there is more and more of this air space, there are going to be more and more violators who throw

up their hands and say FAA will never know the difference if I just flip this switch on the transponder and keep on going. Don't point the finger at general aviation. We know of admissions by off duty airline pilots who also fly small planes, they think they know better than the system and the regulations, and do just this. I wrote that paragraph about a week ago. Last night at the same meeting an airline pilot stood up and said he had been flying into Buffalo for 17 years as a line pilot and he was a general aviation pilot and he hadn't ever once had a near midair collision and he had never once been given a traffic advisory that was a potential factor. I was told later by other individuals that that airline pilot flies an antique aircraft from a grass strip about seven miles from Buffalo on his off duty hours and he is one of the biggest violators flying across the pilot approach course just outside the airport traffic area. Now, if I am to believe any or all of what I heard, that individual is the one that controllers are talking to the newspaper about and that's the one that brings about more and more terminal control, which brings us back to the point that I have made earlier.

Everyone admits -- no doubt everyone in this room will admit -- that we must have the redundancy between the pilots and the controllers in that they watch over each other's shoulders to keep the system safe. Human factors would have a part of this whether only one person had control of the situation and it certainly has an even bigger effect when the responsibility is shared. Unfortunately, too many don't seem to understand that the responsibility is not a whole which is divided among pilots and controllers and does not overlap. Just because a controller's responsibility is increased under radar surveillance does not mean that the pilot's responsibility has been reduced one bit. But, that's exactly what happens in today's system.

The December 1980 issue of the Human Factors Journal has a very interesting article on air traffic control problems. I would like to quote its author, Frank Fowler. Remember, this is not AOPA speaking, these are the words of someone involved in human factors studies.

"What is needed, however, is a comprehensive examination of the ATC system and a reevaluation from a human factor standpoint. The operators of this system (controllers and pilots) must be understood and appreciated in terms of capabilities and limitations. The system must then be modified on the basis of this analysis."

To close, I would like to set the record straight. If anyone feels I have slighted pilots or one category of pilots over another or controllers, I want to wash clean at this point. In fact, I could spend a half hour or maybe even three hours telling you about the mistakes I have made personally with involvement in the air traffic control system just in the last year. So, let me say something good about both pilots and controllers.

Pilots and controllers are highly trained. They are retrained. They are physically fit and, as we all know, they are slightly above mortal. What I don't understand is, since we are slightly above mortal, how can we possible be expected to correct our mistakes when none of us are willing to admit we make any?

Thank you.

MR. PORITZKY: I'll bet you there are questions or comments on what Bob just said, comments, too, yes. Who will start? They are all asleep.

MR. WARNER: Ed, you don't want to say anything?

A VOICE: Thanks for the invitation, Bob. Didn't think I was going to take up the challenge.

First of all, I want to comment that Bob Warner, I am surprised to hear you admit that you are just a student of ATC. Number two, I think you are the worst human factor we are going to have to deal with in tomorrow's work shops.

MR. WARNER: Thank you for your comment.

MR. PORITZKY: Any questions or comments? They are saving it all for tomorrow.

Thank you very much.

Next we will hear from the Air Transport Association and the man making the presentation will be Gary Church who is the manager of Air Traffic Control for the ATA.

Gary?

MR. CHURCH: Thank you very much. I want to thank the FAA for the opportunity to make this presentation even though it has been on relatively short notice. I want to try to make my remarks as brief as possible. You see, my wife is on the gaming tables and I am afraid my checkbook balance is

depreciating very quickly.

I read a very interesting little remark or comment not too many weeks ago about government regulators and government planners and I think it is an overview to some of my remarks and I would like to relate that to you here. The remark was that government planners and regulators are sometimes like new boy scouts. They have a tendency to help you cross the street even though you don't want to go. I think within the realm of human factors and what we are looking at in additional computer aids, computer development, higher sophistication and technology, that I would like to caution the FAA that before we get too highly invested into any particular direction that we make sure that the users can afford to go that way or even if it serves their basic needs, I think that's one question that has to be continually reviewed at every step along the way. I also wanted to make one brief remark -- Bob Orr earlier this morning pretty much capsulized everything I'm going to say so please bear with me. We didn't corroborate these remarks, but they are going to sound very familiar based upon our mutual background in Air Traffic Control.

As you all know, the next two decades hold a great promise of challenge in the field of Air Traffic Control. Unlike the technological revolution that ushered in the jet and computer age upon which our air transportation system has been built, we see no new undeveloped technology yet looming on the near horizon. The future very likely will face an era of diminishing returns where more dollars and more investments are likely to buy smaller and smaller returns in safety, efficiency and productivity. I think we all know that that means that we are going to have to be very careful about what we spend and where we spend it.

It has been said that the one thing history teaches is that no one learns anything from history. Unless the human factor deficiencies right now in the current computer system are accurately analyzed this statement may prove very prophetic for what we have in mind for the future. Although cost limiations or state-of-the-art limitations may not result in a correction of all human factor problems inherent in the current system, the deficiencies still must be progressively explored and accurately and completely identified if we are going to realize the full potential of the next generation of computer system. We realized over the last few years since the implementation of FDT and RDP in '74 that we made some very significant gains in productivity, especially in con-

troller productivity. These gains have been made possible by automating many of the time-consuming tasks previously requiring oral communication. However, these increases in productivity due to technology have not necessarily imparted human factors benefits. As we all know or at least those who are familiar with the present system know, the current system is demanding, requiring and displaying great quantities of information and data. The skill required to interface this system may be unnecessarily and artificially complex, requiring excessively high training standards which undoubtedly add significantly to training times and their subsequent costs. Restrictions in en route capacity are often incurred because of the inability of one controller or even a team of controllers to satisfy the tremendous quantity and complex requirement for data input. In other words, the system itself, the computer system, may artificially establish some human factor limitations and human limitations. For example -- and let me pull some of these on our current system -- for example: The physical layout of the controller radar display, known as the Plan View Display or PVD, is a prime example, really a questionable system design from the human factor standpoint. If you look at it very closely you will notice the uniformity of entry and display keys in size, shape, and alignment results in an unnecessarily high rate of computer entry errors. To illustrate, as a controller's work load increases he focuses more attention on the radar displayed track data. The result is less visual attention to the physically undistinguishable computer entry display keys and a subsequent degradation of eye and motor coordination. This induces a greater rate of computer entry error when productivity requirements are the greatest.

Computer formatting of the entry and display of data have unnecessarily added to an increased error rate and a lowering of productivity. One of the most frequently used computer entries, the temporary or interim altitude, requires up to ten physical movements to generate a single displayed altitude upon a radar scope. This problem has been well stated by Donald Connolly here of NAFEC of the Tech Center and I would like to quote what he has written.

"At present, there is only one channel through which controllers can transmit essential facts to the automation system: through their fingers. The keyboard 'language' that must presently be used to communicate these data to the computer system is artificial, encoded and almost absolutely inflexible, difficult to learn and remember, subject to error, and a source of distraction to the user."

Unfortunately -- and I will reiterate that unfortunately -- a focus on "knobology" has been all too quickly dismissed by many, many system designers. No single aspect of human factors can be slighted or ignored in system design or development. The report of the President's Commission -- and here's where we pick this up -- we have heard this for the third time today -- the report of the President's commission on the accident at Three Mile Island Nuclear Power Plant made it plain that the lack of many human factors considerations contributed to the operator errors which resulted in that near disaster. Difficiencies in training, lack of clarity in opeating procedures, failure of the organizations to learn the proper lessons from previous incidents, and deficiencies in the design of the control room all significantly contributed to operator error. These conclusions could just as easily apply to an analysis of any number of Air Traffic Control Systems errors. The significance in all aspects and elements related to human factors are important. I would like to read another quote, if I may, from John W. Senders who has written an article in Psychology Today:

"The search goes on for ultimate theories of monitoring and controlling. For a variety of reasons, most of this work ... has not been applied or understood by the designers of kitchen stoves, automobiles, and nuclear power plants. It has occasionally seemed as if designers have taken a perverse pleasure in doing things the wrong way - ignoring data, published reports, the council of experts, and even common sense."

Further illustrations of what I would like to consider human factor deficiencies in the ATC System today is the radar scope display which has required some modification to a non-glare glass but still causes a significant lighting problem within all of our twenty air route traffic control centers. This low ambient lighting level may be a factor conducive to eye strain and fatigue. Although the FAA has already made some lighting modifications, the poor lighting conditions still remain unresolved. I don't think that within the context of the presentations here today that you saw any potential resolution for that problem. We still will face that factor in the type of facilities that we have today. The severity of these lighting problems are due to the nature of the design of the current generation computer system. The change in viewing angles of the radar scope from six degrees inclination to sixty-eight degrees inclination and a much darker radar display background with the RDP

have created -- and I will call them negative benefits -- by increasing the effect and susceptibility to light and glare over the old broadband mode of operation.

The automation requirements of today's computer system have transformed many of the roles and responsibilities of the controller. I will try not to list or enumerate many of these in my opinions, but we know that one thing which has happened is there is an increased system capability which has resulted in a shift of emphasis from preplanning of control actions to circumstances of reacting now to control situations. The workstation or team sector concept is in dire need of revision to more adequately apportion responsibility and work load within an operational sector based upon human factors considerations. We have also other factors in the system that emphasize that development of a systems approach in responsibility by each individual air traffic controller. Through expansions of integrated flow management we will also have a significant impact on what type of data and responsibility each of those controllers should have. This is necessary to integrate those expectations into a revised system and human factors analysis.

The balance of work load between operational sectors is another human factors consideration that really cannot be ignored in today's system. As users we suffer penalties on a daily and routine basis. Although traffic flows shift within a center because of weather or route demand there remains little flexibility within the current automated system to respond to a variance of need. Center and sector boundaries remain rigid. A control of work load can only be accomplished by a pre-established automated plan which combines or de-combines sectors, or a control of user demand by flow control restrictions. If we do a more careful analysis of human factors requirements it could lead to a system of flexible geographic responsibilities within a designated control area which would benefit not only the controller but the system user as well.

Many other factors relating to the efficiencies of system design may be questioned in today's automated system. Failure modes of operations, types and nature of data presentations, distraction phenomena are just a few. Substantial increases in both safety and productivity may still be possible within the current generation system given a commitment to improvement by the FAA. Considering the current government fiscal policy, this may by the only reasonable near term solution to the pressing problems of continued aviation growth.

The success of the future generation computer system for air traffic control is dependent upon bringing together a variety of concepts, those which are technological, procedural, and human factors, into a well orchestrated system that will maximize efficiency and minimize cost. However, we do not want to get into a mode of operation where we are a victim of our own technology and I would like to call it to subscribe to the "gismo-gadget syndrome". This is where we develop technology just for technology's sake and we don't clearly understand what our objectives are or what we are trying to accomplish. We have seen many experiences and experienced many circumstances in the past where the technicrats will develop square pegs and having given them to the bureaucrats, they will attempt to drive them into round holes. It is not an efficient way to run any system, much less the Air Traffic Control System.

In the broadest sense human factors -- and I will attempt my own definition because I have seen a myriad of definitions and I don't know which one is correct -- so, my definition of human factors is the relationship of man to himself and his environment. It is of the broadest scope and the broadest nature. If technological innovation and development does not serve the needs of man and cannot integrate with his limitaions, abilities, and expectations, its value is certainly questionable and limited. The value of the new generation system cannot only be questioned from a cost to productivity benefit ratio but also its value to impart human factors benefits. According to Dr. W. Edwards Deming, and he is the widely recognized mentor of Japanese productivity that we have heard so much about of late, he says that extensive capital investment does not necessarily equate to higher productivity. We cannot always solve our problems by throwing more money at them. The sure way to increase productivity according to Dr. Edward Deming is to better integrate man and his machine.

The need for a thorough documentation of human factors has been demonstrated -- and we have seen it here today -- but is has also been demonstrated by an extensive literature survey done and published in July of 1979 by Rudy Ramsey and Michael Atwood of Science Applications, Inc. They concluded that insufficient data exists to develop a much needed human factors guide to computer system design. We therefore -- or at least I am going to make this assumption -- that superficial studies of human factor considerations will not pay back necessary dividends to the investments required in a new generation computer

generated system. New automated control concepts which raise new human factor issues must also be addressed during system design, and a new kind of meaningful role establihsed in which the human can interact with the computer.

Again let me read another quote from John Senders:

"Although there are many small failures and a few large ones in these systems, they are, overall, remarkably reliable. This reliability is the basis of a paradox: The human operator has virtually no actual experience doing the thing that he or she is put there to do. Therefore, the more reliable the machine, the less reliable the human operator."

Automation efforts should foster and support the human contributions of flexibility, adaptability, and creativity to system control. The challenge will remain to construct a machine compatible with man rather than to force man to function as a machine.

Aside from the potential productivity benefits of increased automation, the major emphasis is on increased safety. Technological concepts and state- f-the art developments may enhance software and hardware redundance and reliability, but the reduction -- Bob Orr, where are you, you would love to hear this -- but the reduction of simple human error by proper consideration of human factors may provide the greatest system benefit to increased safety.

The study of the nature and cause of human error is absolutely essential to design automated systems to minimize human generated error. Donald Norman, Professor of Psychology at the University of California at San Diego has categorized three types of mental errors. These classifications are called description error related to abstract reasoning, activation and triggering errors related to memory, and capture errors related to habits of behavior. Each of these categories explains a type of mental slip that leads to a human error. By understanding how human errors occur, it should be possible to design computer systems to block errors by selectively forcing functions which detect specific types of mistakes. Mr. Norman again writes:

"In industrial, aircraft, and nuclear accidents, my analysis indicates that the system is most often at fault, not the operator. People make errors as a fundamental by-product of the same information processing mechanisms that produce their greatest flexibility. Yet system designers ignore both human strengths and weaknesses, and today's systems sometimes seem designed to cause

the very errors that they should be set up to prevent."

An example of some creative work that has been done -- that is being done -- experiments conducted in voice generated data entry in air traffic control have produced some rather significant results. In over six thousand message generations, both by tactile and voice instructions, the voice system produced 65 percent fewer errors of all kinds than the key board entry method. These results indicate the tremendous potential for increased safety in a field so reliant upon accurate, pertinent, and timely communications. Further, the consideration of the full range of human factors engineering becomes even more important in developing the future generation system if these types can be realized. To bring together fully developed issues of technology and human factor considerations will ultimately determine the success of the Air Traffic Control System into the 21st Century. Let me digress for just a second. I want to tell you a little story, everyone is getting a little sleepy out there and maybe this will perk you up a little. This is a story about an old bull and a young bull.

This old bull and this young bull were walking on top of a hill late in the afternoon and all of a sudden this young bull, he got very excited. He pokes the old bull and he said, "My God, look at all those young heffers out in the field." The old bull turned around and he shook his head and said, "Yes". The young bull, he says, "Let's run down the hill, jump over the fence, run down into the meadow and make love to one of them." The old bull he says, "No", he says, "Let's walk down the hill, crawl under the fence, walk slowly and make love to them all." Now, that's creative thinking and it's good planning and it's deliberate actions and that's the kind of elements that we need to come out of this endeavor this week if we are going to get the kind of dividends we need in our investments in the National Air Space System.

I'm just about done and I'm just about broke, I'm sure.

The conclusion is that with all of our technological sophistication we are only now discovering how to relate man and machine and it is a very startling revelation; it was to me when I started delving into these issues. But this challenge and many others belong not only to the FAA, but to all of us in the aviation industry. If we are to produce a system of increased productivity, efficiency, flexibility, and safety, all of these things must be produced at a price which will be economically beneficial to the FAA, the system users, and

the American public.

Thank you very much for your time.

MR. PORITZKY: Thank you, Gary. Any questions, comments? Anybody? You got off scot-free.

Let me turn now to the Air Traffic Control Association and the man that will make the presentation on behalf of ATC is not the man shown in your program. Instead he is Al Kulikowski who is the Center Chief of the Anchorage Center.

Al, the floor is yours.

MR. KULIKOWSKI: Thank you, sir. We in Air Traffic Control Association are pleased to participate in this meeting and we appreciate the opportunity. Before I start, I'd like to mention one thing to Bob Warner, you left off Alaska bush pilots. They are a different, special kind of breed.

I guess my interest in human factors is evidenced by the distance I had to travel to attend this meeting. I was impressed with the presentations by the different speakers, the number of people attending this meeting, and I am sure -- equally sure -- that during the next two days of the work shop sessions, some of this talent, experience, and knowledge will go long ways towards making some of these ideas reality and incorporating them into Systems Design. I was especially interested in the presentation by Mr. Blake. The presentation was both informative and, I think, challenged our imagination to come up with the ways and means to incorporate human factors in a system design for a new generation of computers as well as sectors. He spoke about new concepts, additional equipment, additional automation. The big question is: How is this information going to be displayed to the air traffic controller? It is a big question and I think that during the next two days most of us will be busy trying to provide some of the answers. The question is certainly open to our ideas and recommendations. We all know that human factors are critical in a controller work station design. The sector suite was quite an interesting concept. How about sector design in the same fashion in the cockpit and aircraft design for the controller so the controller can reach all of his switches, controls, and information available to him?

The presentations made by other speakers touched upon all aspects of Human Factors and I don't think I need to repeat any of them. I would, however, like to give you some of my observations and perceptions as seen from the field

facility, the Air Traffic Control Center. Again, let me just state a few observations and a few human factor problems that we are experiencing today. Our current ARTS, 9020, and EARTS problems are daily problems and I don't think that we will have any great deal of solutions until a new generation of computers is with us. I think Gary talked about PVD glare. It is a big problem that existed with us for some ten years. So far there is no solution to it. Alongside of the PVD glare we had the controller room lighting. It is poor in most cases. How about location of control boxes either PVD or associated with them or on console? How about the incomplete interface with some of the other facilities? One center to two ARTS, three facilities or centers to ARTS-2 or, in my case, EARTS to ARTS-II facility. There is no interface at the present time. Some of the inefficient programs, the programs/computer input functions, the computer limitations, there could be some improvements there.

One of the big problems we have in our offshore centers -- Anchorage is one of them -- is lack, complete total lack of automated oceanic traffic situation display. We have had the IDIOM, we have tested in Oakland Center ten years ago and it is gone and forgotten. We don't have any situation display at all. We could use it today.

How about our current problems with sector design in the centers again? The M-1 console or the boards as we call them, is really outdated. The inline concept does not allow the controller easy access to all the switches and controls that he needs to have. After all, the controller's arm doesn't get any longer and how many pieces of equipment does he really have at his eye level? Not very many. We all know the most efficient location of any equipment would be at eye level within easy reach of your arm. Again, I would like to emphasize that we need to take a look, a hard look, at our sector design and design the sector around the controller in the same fashion and I mentioned before, as a cockpit in an aircraft.

We all know controllers have many frustrations and, as they build up, their control efficiency suffers and the chance for system error increases. The equipment that we use in the equipment room down in the basements, that equipment room must be flexible not hard wired as it is today in most cases. Why should it be flexible? Because our system is dynamically flexible. It changes with the volume of traffic. We need to make changes for sector design, sector location, physical location, and we can't be waiting for two or three years to

change that. We should have a patch panel situation where control sectors can be changed and modified within days, not months.

We have talked about weather distribution systems which we don't have today, weather radar. All that information should be available to the controller on a real time basis at the time he needs it so he can transmit it to the pilot. The problem is the information is available in the system but not where it's needed. The weather display should be located at the control sector so the controller can have easy access to the vital computer so he can transmit the critical information to the pilot, the pilot is to know the signals. All that data is necessary.

How about airport data, landing data? We have had several incidents in the past where that critical data was not passed to the pilot in timely fashion. Therefore, we had several cases of accidents and subsequent suits where the FAA or the government had to pay a lot of money because of our failure to provide that information. Surely if the money was spent to obtain that equipment we needed at the control positions we could avoid some of those situations.

I think that Bob Orr mentioned in his presentation an excellent controller viewpoint in facing these daily problems. The problems in automation, boredom, complacancy, we have heard these before today. The problems are real; I don't have any solutions to it. But, as somebody pointed out earlier today, the controller needs to have some sort of a memory jog to keep him alert so he can concentrate on the task at hand. As we become more and more automated the controller has more and more difficulty maintaining awareness of what's going on. As Gary mentioned a few minutes ago, he needs to anticipate a plan, not react to the situation already happening; it's too late. The only way he can stay alert and anticipate is if he utilizes as many of these natural senses as he can. In all broadband situations control utilizes all of his three senses to help him update his memory. He had a sense of touch which was utilized by pushing the shrimp boats or markers along with the traffic targets and does update his memory continuously as to what the situation is. He utilizes to a great extent a sense of hearing; waiting for pilot reports, altitude reports and other critical information. Today the sense of hearing is not used very frequently. Why? Because most of his data is displayed on the PVD in front of him. Therefore, he is depending almost exclusively on his sense of seeing data and thus reacting, not anticipating. Yes, the controller has a great

deal of difficulty in staying alert and being aware. We must do something to help him, he must have a way to update his memory frequently. He must be, in fact, forced to update that memory and concentrate in order to prevent system operation errors. Because of our automated equipment and our tendency to observe all the data that we have to have in order to make control decisions, we also have a tendency to avoid verbal coordination which in previous years was so critical and so very effective and as we call it in our trade, "making deals" and moving traffic. Too many times today a controller will depend on adjacent control and an adjacent sector or facility to observe that data on his scope and take necessary action in time to avoid a problem. Well, before automation the controller did not wait for that. He took some specific positive action to accomplish this task.

How about the tendency to develop poor listening habits? It's here. I think that we talked earlier -- I think Dr. Kinney spoke about the learning and listening habits. Well, most of us humans are poor listeners. We talk very good, but we listen poorly. How about the comments by Dr. Kinney about listening and connection? The connection is missing; you have to have it.

And last, but not least, we have increasing difficulty maintaining our precise positive communications because of automation. All of those tendencies are compounded by the fact that, as somebody mentioned earlier, again, we have a tendency to hear what we want to hear and we have a tendency to stop listening after we hear what we want to hear and then a tendency -- as we call it in our profession again -- betting on them to come. Sometimes a bet doesn't pay off; we can't affort to gamble.

Almost exclusive dependence on seeing all data on radar, on PVD, hampers controllers' ability to concentrate and maintain their work. We must do something to help them. The controller must maintain a picture of a constantly changing air traffic situation. Those problems will be compounded in the future as we add more and more equipment and more and more automation. I am of the opinion that the increased automation equals the increasingly passive controller role.

We have heard before that future generations of controllers will constitute traffic managers controlled by intervention and controlled by intervention and controlled by inception. I am not sure this will work. How is this controller

passively watching the information in front of him, going to be able to anticipate -- not react -- anticipate, and head off critical traffic situations? I don't have the answer to this. I think we have enough talent, experience, and knowledge and our talents from academia can deal with those questions, hopefully, and give us some answers.

In view of increased automation the question is: Do we seek out the same aptitudes of controllers in the future as we seek out today? The typical controller of today is aggressive, innovative, he improvises, he is flexible. He is not geared to be passively watching a PVD scope with 15 or 20 targets passing by, displaying all data he needs to have. Maybe we ought to look and see what kind of aptitudes he will need to have in order to have control managers, control by innovation rather than activity controllers which we have today.

In closing, I think that it is very, very important that during the next two days all of use involve ourselves actively in trying to design equipment that incorporates all of those human factors that we talked about here today. That the future generation controller as well as the equipment are compatible. We must build a machine around the controller. The work environment will change, we will have to deal with those issues. Bob Orr again mentioned working hours, breaks, fatigue, all of those things. That is a part of the human factor. Finally, how about pilot interface with a fully automated system, air traffic control system, data links and the like? I don't think I need to remind you that this meeting is important, it is critical in fact, because hopefully this time our comments, suggestions, and recommendations will be incorporated in a second generation traffic equipment -- automated equipment -- Stage B, you may call it. We will discuss those issues during our work shops here during the next two days and all the ideas from all fields and all disciplines I am sure will be relative.

Thank you.

MR. PORITZKY: Thank you Al. Any questions, comments? Scot-free.

The last of the people who indicated that they were going to make a presentation is from the Professional Airways Systems Specialists and Howard Johanssen, the President of that organization, will speak to us.

Howard?

MR. JOHANSSEN: Thank you; I know it is late. I'm not going to take too much of your time. PASS is happy to contribute to this meeting. I think it is only fair since PASS is rather new so that I will explain to you what PASS is. The name, Professional Airways Systems Specialists was derived from basically what we do: We are airways facility technicians. Technician now is a dirty word for us as maintenance man has been. That's why we call ourselves Systems Specialists. We are involved in the total process of giving the controller both sight and hearing not to mention twelve or thirteen other different functions. We are new on the scene but we are here to stay. We have something important to contribute, and I hope everyone listens.

Some of the human factors that we face were addressed earlier today by Gerry Thompson of the FAA. The design of machine to man concept is an important concept that we face because we are a part of that transition role. We feel that as the machine is designed around us we too must have an input. We must be part of that design process.

In the past, most systems of the FAA have not given us that ability. Perhaps that is one reason why some of the past systems have had as many errors as it has had. In the future our solution to that problem, the design problem, is give us a chance. Give us a channel, we want to contribute.

The FAA has ten thousand of us in the field responsible for the systems that you people must live with. We are like that mechanic that Jerry mentioned earlier today that changes your oil. In the future we will continue to change the oil, but we want to be more than just that mechanic. Within our specialties we have five areas. It is the environmental area, NATCOM, the data and radar areas. They all will be going through a drastic change particularly of responsibility in the roles that our people play. We are not sure that we are ready to accept that change. The FAA has a lot of convincing to do before we will, but we are willing to participate, we are willing to be reasonable, we are willing to offer solutions.

The transition from preventive to corrective maintenance is on the horizon. The PASS system with preventive maintenance has provided a good overall system for the user, the entire aviation community. We are alleviating the system that works into something that we who are responsible for it cannot agree will work. The basic overall concept of the new system on paper in the minds of

the engineers who are developing it is fine. But, we for too long have lived with those systems that the engineering level considered to be fine. We won't accept it any longer; we will work with them. In the past we have helped them correct their engineering marvels. So today we have a system that is held together by baling wire, band-aids, and whatever else it takes to make a system work. The transition will mean a lot to some of the older people in the system. We have a different philosophy of employment.

Myself, for example, I have five thousand classroom hours in different equipment courses in basic theories, the things that are needed or that I need or the FAA needs to do the job. I am not unusual. Most systems specialists have anywhere between four and eight thousand hours. Our entire industry is going through a change where they now once again have to go back to the classroom, leave their families most often to go to the Academy in Oklahoma City without -- without -- the possibility of advancement when they return. For the last two decades they have been very dedicated and accepted that role. Our financial status as it is today is not so much the responsibility of the FAA, but that of our economy. The methods in which we are paid has a very great bearing on the human factor. The competition in industry today provides, fortunately, for our people an outlet, one that the controller does not have.

In the last year and a half I have traveled a million and a half miles in this system. There are very few facilities I have not been to. I have commented on FAA's equipment, I have testified before Congress, I have criticized the FAA. But criticism will not do the job for the FAA. The role we must achieve here is to start doing something that is not totally selfish for our own interest. PASS is a labor organization, but we are a responsible and a responsive one. There is another organization within the FAA that I have heard comment to from time to time and perhaps their tactics are not one that everyone in this room agrees with. It is unfortunate that they have gone to the extent to bring about change. I hope my organization will not have to do that.

There are many pressures that FAA faces. One is labor/management relations. Others are the funding and financial responsibilities they must maintain so that they can do their job. Unfortunately, Congress controls most of their purse strings. I have testified approximately ten to fifteen times in the last few years but I have heard very few comments from the Aviation Industry recommending that the FAA gain further funds so that they can support the

changes that are required to provide safety that you people here need. What are the solutions for that human factor, because that whole funding process either makes or breaks an individual's stay of employment on the job is to support them. Criticize them, but support them. I haven't seen much of that.

We have spoken on some of the design areas in the past. Those are the mechanical things. We have the intelligence, the ability, the desire, and the dedication to change those things. But the support is the solution, ladies and gentlemen, the support. The fact that you are here right now is a good start. But you have to lay aside your individual interest, your organization's interest as my organization proposes to do here today, and set an example of what we have to do with this system.

Now, there are going to be times through this transition that Gerry Thompson and I, or any other FAA, or whomever it may be, will be fist to fist, eyeball to eyeball. But that's necessary and it's healthy and I hope you will all understand that.

We propose to make this the best system it is or it ever can be. I viewed the transition as one that I witnessed an aunt once go through. Perhaps this is going to be the biggest wedding arrangement that we have ever seen. Now, if any of you have gone through the process of arranging a wedding for your daughters, sons, or yourselves there is always the unexpected that occurs usually at the last moment. The bride is the NAS system, the groom is the people in it.

Before I close, I would like to offer a word of caution. The members we represent absolutely demand that we carefully evaluate their new role and address the issues in the transition to the new system, the system selections, the training, and the proficiency levels necessary. The transition to the future system without the systems specialists input and approval will have a devastating human impact on the entire airways facility work force.

Thank you.

MR. PORITZKY: Thank you; are there any questions, comments?

Would you please identify yourself and tell us your affiliation?

MR. BERRY: My name is Bob Berry (phonetic), I am a controller of the Washington National Tower and a training instructor and I am also with PATCO.

I am on the PATCO National Safety Committee, I took over three months ago as the Eastern Region Representative. My questions are not necessarily directed at Howard Johanssen.

I just want to make a couple of comments especially since everybody seems to be tired and there doesn't seem to be much energy for bricks, so I can get up here fairly safely. I agree with Howard on many of the things that he said. There are so many experts in this audience that it is a pleasure to hear everyone. I am not here to criticize the FAA. I believe there are many, many good people in the FAA. Unfortunately, there is breakdown on many occasions between the work force and high level management and in many cases your first line supervision. We work with equipment like Howard indicated that needs to be looked at now. The programs that are down the road, the E-TABS, TIPS, and DABS, all the other acronyms are very nice. The controllers will adapt to it.

There was a gentlemen from the Technical Center that had a comment which I was not too happy about as a controller -- but he is entitled to his opinion -- who questioned the concern of the controllers. As a controller at one of the busiest facilities in this country I assure you that when we train people we train them for only one thing: To run airplanes, to run them expeditiously, safely, and sometimes even if that is illegally, as we know we do, to move the traffic, that should be common knowledge.

I cannot address some of the excellent topics that came from Dr. Kinney or other experts in the audience. I am not that familiar with many of them. I am trying to do as much research as I can, my main job is as a controller. In the meantime we get briefed. I was here at NAFEC about two weeks ago to get briefed on some of the systems that are coming down the line.

The controller work force can be and should be one of the most content work forces in this entire country. Controllers like and sometimes love to work airplanes. It's that simple. I am not trying to pull anything over on you. We like to work airplanes. Pilots love to fly airplanes, we like to work in a system. We know there is a difference, the pilot is in command of the airplane, but we like the job that we do. We get frustrated on many occasions because of things such as equipment. We bring things to the attention of people and because it is PATCO that brings it to the attention of people it immediately becomes a mute issue, it becomes a pay issue, it

becomes something other than what is true. There are problems in the field, they need to be addressed now and not by something that is expected in 1990. We know the ideas that the 9020 computer system integrated the ARTS and brings ASR radar line into the centers, et cetera. The 9020, we know, has reached capacity basically. The controller frustrations have reached a point where they have affected morale. Controllers want to work airplanes but more and more they take a look around them and say, "Is it worth it?" Mr. Weithoner in "Aviation" terms us as high school graduates who should not be making $50,000.00 a year. I'm on the Level Five Facility and I did not make $50,000.00 a year in 1980, I made $38,000.00, GS-14. I do not consider that unreasonable. I will not get into the contract.

The controller work force should deal with the FAA on a professional level. Many controllers no longer say they are in the FAA. They say the controllers and the FAA. This is not just an issue brought about by PATCO. Many controllers are not necessarily staunch, go-getem' union members. That's a fact. But in recent years the greatest ally that any union in this country has had sometimes is their employer and that's the case with PATCO and the FAA. Many of the policies instituted by the FAA have caused even the weakest non-union persons to join PATCO, because of their frustrations.

You talk about standard operating practices, Dr. Kinney gave an excellent presentation. Standard operating practices are very good. We want them, the controllers want to participate in the process. We want to be accepted. Unfortunately -- and why I don't know -- controllers seem to be alienated from the projects that go on in many of the other organizations that have professional status in the aviation system. If you let controllers get more involved you will see results. Just as the pilot can take an airplane and take a system that goes into it and say, look, here's what we can do; so can the controllers do with the equipment and the various items that come out in the future. You talk about standard operating practices, well talk about Washington National and then I will talk about Boston Logan. Logan has one of the worst reputations around from what I can gather talking with controllers and pilots.

Is it necessarily the controllers up there who enjoy slowing airplanes down, who don't want to run airplanes in as fast as possible? No. The procedures are different. For example, in Washington Center I can key a land

line and tell the guy out in the center: "hey, I don't need ten miles in trail, let me have that guy, don't slow him down." Can they do that at the Boston Center? No. They have to go through a metermaid. The metermaid sets up the sequence. If a controller wants to talk to another controller he is not supposed to use the land line. That's the facility chief.

There are many positions of authority in the FAA that have people in them that do not respect the controllers, that should not be in those positions because they are not good managers. There is nothing wrong with supervision. Controllers do not resent supervision, they resent poor supervision. In many cases that is what we have. Macho controllers? The gentlemen from AOPA was right, we have some of those. Give me all you can take -- or, give me all the airplanes you can, I'll take them. We've also got the guys who say, "Now is it the slow time?" "Can I get on the position now?"

Without getting really drastic or whatever terms we might want to use -- melodramatic -- I work with one gentleman whose medication is nitroglycerin. A gentleman takes nitroglycerin in order to come to work; in order to live. He is not supposed to, he takes it. Why? Because the FAA flight surgeon said nothing's wrong with him but his three doctors did.

Senator DiConsini's office received a briefing from OPM and OWCP. OPM advised the Senator's office that regardless of the validity there was a directive out that all controllers' request for medical retirement be turned down.

There is a man with 23 years of air traffic control service to the FAA, to the government, and to the Aviation System that is out on the street right now without a retirement of any sort. We are putting up money every two weeks for him, as they are in Phoenix. He said according to his doctors -- several -- that he had extremely high blood pressure. The doctors did analyze, came up with that conclusion, and said it was related to his job. You can believe that or you can put it off as PATCO propaganda; I am telling you that it happened. The man went to the FAA flight surgeon, he told him that he should take half the medication and come to work. His private doctor said, "if that man takes half the medication he will have a stroke." The FAA surgeon said, "well, that's the way it is."

That's the type of attitude that controllers are facing in the work force. Just as standard operating practices and new equipment are to human factors,

this is a critical issue. Controllers want to work with the system but, you've got to get a little bit of cooperation, too.

MR. PORITZKY: Any further questions or comments of Howard? Okay. Are there any other people in the group who would now like to make a brief -- I hope -- presentation or express comments or other views that you would like to have the whole group hear rather than to bring it up in the work shops tomorrow?

Ed Krupinski?

MR. KRUPINSKI: This will only take a few minutes. It's kind of tough to follow the last two guys, though.

On a serious note, ALPA would like to have made a formal presentation on the human factors in the system, but our decision and ability to attend this conference came a little bit too late for us to make any presentation. We were asked, however, if we would make a brief statement with respect to our views on why we would want the cockpit display of traffic information developed and if I may, I will just quickly read this:

"For the past several years ALPA has been advocating the development and need for cockpit display of traffic information. We understand this has generated some concern in the minds of some people who are asking the question, that if this capability is made available in the cockpit is the intent that the pilots will take over traffic separation and responsibility negating the need for air traffic controllers? The answer is pure and simply: no.

ALPA has, on numerous occasions, stated that separation responsibility is now, and in the future should remain, a function of the ground air traffic control system. As we all know, though, heavy reliance is placed on the 'see and avoid' concept for several reasons. First, by its very nature the United States Air Traffic Control system has always permitted and probably for decades to come will continue to permit a mix of VFR and IFR flight operations. Secondly, because of the system's inability to separate all traffic, VFR flight will continue in growing numbers. Because of the controller work load, radar limitations, traffic information is not always reliable or even accurate or available. Finally, visual approaches and clearances' is the general mode of operations today. For these reasons ALPA is convinced that a cockpit display of traffic information is needed to reinforce the pilot's ability to cooperatively work with the controller and assist the pilot to 'maintain visual

separation'. With the proper tools and accurate CDTI and ground automation we envision the controller work load can be reduced, and traffic expedited, based on authorizations for self-separation which are made by the controller on the ground.

In summary, ALPA does not view the cockpit display of traffic information as a means of taking over the controller's responsibility. Much work, however, needs to be done to lay out the roles and responsibilities for the pilot and the controller in a highly automated ground system and improved cockpit capability." Thank you.

MR. PORITZKY: Thank you, Ed.

I might comment that as I think I indicated this morning -- perhaps it was Neal -- there is an extensive program jointly managed by NASA and FAA on cockpit display of traffic to deal with some of the issues that Ed raised, to look both at the potential roles of such systems in the air traffic control system and to look at the liabilities, because there are some of both. Should that matter come up tomorrow Harry Verstynen is the FAA program manager on the CDTI project and if it should come up I know he would be delighted to talk with any of you tomorrow or during the cocktail hour this evening.

Any further comments or presentations?

Yes, sir? Please identify yourself and give us your affiliation.

MR. ROSS: I am Jon Ross, Los Angeles Tower.

Being a working controller in Los Angeles, I talk to hundreds of airplanes every day. It doesn't bother me a bit, but put me fact-to-face with those hundreds of people that I am talking to and I've got to hold on to something and it's not a radar scope, it's going to be this platform this morning. I think I fit what Bob Warner mentioned a little bit earlier, I am that ultimate macho controller that he mentioned. But, there is also something else that was mentioned earlier this morning. I am also a very dedicated individual who is interested in knowing and working with the System. Mr. Orr mentioned something this morning that triggered my desire to get up and say something to you before we get into our working sessions tomorrow. He indicated that the average experienced level of controllers today is about ten and a half years. This is a young man's profession. It has been for quite some time, and it is going to be for quite some time in the future. As a controller at Los Angeles

the last six years I have watched people come in after I have arrived there and they seem to get younger and younger every day, because I know I am not getting any older every day.

We viewed a film in our facility a few months ago, the title of the film was, "You Are What You Were When". Some of you may have seen this film. It references the value system that you and I have and how they were developed. Those value systems, when they are developed at a very young age, stay with us for a very long time. As new generations come and old generations go, those value systems tend to change. Those value systems determine just about everything that we look at in our lives.

We have a broad extensive background of experience in this room today, most of you not directly related in the Air Traffic Field, but at least very familiar with it and, you are here with one intent, that is to look at the systems and at the controllers and at the facility systems people and see what human factors are involved in developing the future Air Traffic Control System.

What I'd like to pass along to you and ask you to consider -- and I am asking this of each one of you as a controller -- is that you think about the value systems that you have, the value system that you were brought up with, and what the controller is faced with today. Our young controller comes into a busy facility like Los Angeles, he has a background in computer technology, he has been playing with calculators at home since he was four, and how many of you can say that? I can't. They are a lot younger than what I thought of when I first came into the system and they know a lot more about the systems and what's available today.

As was mentioned a little bit ago about some of the frustrations of controllers, part of the frustration is they look at the private industry and they know what is available in private industry. They know what the private motivated companies can put together in their systems and they question why has it taken so long for the FAA and for the industry to upgrade the Air Traffic System to that same level of technology. So, they are aware already and they are a little bit impatient. I think all the young folks today are a little impatient. That goes against the value systems of most of the people that I see in this room today.

So, when we go into our work groups tomorrow -- and I am looking forward to the work group I am going into -- think about this value system concept.

When you think about the human factors that are related to what that controller needs and what that controller wants in the future systems, put yourself in his shoes and not in your own shoes. Thank you.

MR. PORITZKY: Thank you, very much.

I think I saw another hand over there -- yes, please?

MR. ROSSMORE: My name is Allan Rossmore and I am an aircraft dispatcher with the IAM, Eastern Airlines in Miami, Florida.

I know you're all anxious to go to the cocktail party, so I won't keep you but a minute. We have been talking basically about ATC today and I just wanted to put a reminder in that myself, as an aircraft dispatcher, I am on the fringe area of that. But I hope people think about us, too, when they think about these new systems and what the requirements are for the future aircraft controller. We are involved with flight planning, we're involved with severe weather avoidance, we are involved with traffic advisors, we are involved with anything that will affect the safety of the flight on the airline operation. We are jointly responsible for the pilot in command and for the safety of the flight, and what we have been finding is not just with ATC, but with the flight crews themselves, that since flight dispatchers now are so computerized it is much more uncommon now to communicate on a routine basis with the flight crews. They come in and they check in for their flights and they are on their way and they usually don't even call on us unless there is an unusual problem. Now, the same thing is true with the ATC system.

It would be very helpful to us if the ATC System communicated to us on a more frequent basis to tell us that La Guardia has runway thirteen and thirty-one working right now, to let us know what the traffic situation is in La Guardia. Then, that would mean we can communicate that information to all the flights we are working and help everyone.

That's all I have to say, thank you.

MR. PORITZKY: Thank you, very much.

Any other comments or presentations or suggestions? I see none.

I'm not going to try to summarize today's session. I do want -- I couldn't if I tried -- but I do want to make a couple of statements that I

think may be of some use in the discussion tomorrow.

First of all I will make this as a statement: No one really wants to design a dumb system; and I will leave it at that. Most of the systems that are in being in FAA's inventory are not dumb systems. Can they be better? Of course they can be better.

The second point I want to make is to comment on something Gary Church said or implied earlier, that we need to be careful before we waste a lot of money on technology to solve problems which don't exist. I think the prospect of that in the environment in which we live and, in fact, since I have been with FAA, the prospects for that are very small. The question is far more likely to be: Which of the pressing needs can be met? Gerry Thompson talked earlier this afternoon or this morning, I don't remember when it was, about some of the ancient hardware that's out there. It needs to be replaced and it's damn expensive to do so. So, that's no longer a question -- if it ever was a question and I don't think it really ever was -- as to whether we can find problems to deal with the technology that somebody offers us. That's not the issue, it probably never was, and it surely will not be in the future. The things that are being done, the kinds of automation things that are being studied are to resolve very specific problems; fuel wasting, controller productivity, improved technician, operations, that's where the money is going to go.

There is a third point. There is no automation in terms of automatic decision making in the system today. But of all of the processes that we have -- and there is a lot of automation in the system -- none is of the automatic decision making variety.

I hope you will address yourselves to that question. The AERA experiment, the feasibility experiment that is now being viewed carefully, particularly by the Air Traffic Service people is a first tentative step to real automation of the decision process. There is being published currently -- and I wish it were available now, but it isn't quite yet -- an AERA concept document which deals with many of the issues we have talked about today.

I think, again, in the work shops there are people here from MITRE, there are people here from FAA who are deeply involved in the AERA effort. They will be with you in the work shops, I know, to offer you what they know. But again,

they want to know more about what you know. That will help.

Comments were made about participation in the design of new systems and to the best of my knowledge and understanding I don't know of a single new system that has been introduced into the FAA inventory which has not had participation, particularly from controllers, prior to its introduction. Almost all the systems I am aware of come to the Technical Center, are run out at great lengths, very often and in great detail with controllers from the field before they are introduced. I think you need to be aware of that.

Finally, I am going to talk a little bit about the process from here. You will hear more about this, I am sure, on Friday from Jack Harrison but, because I think it is important to your work tomorrow, let me give you a feeling for the process that FAA expects to go through after we have had the five work shops of which this is one. Each of the work shops will have a published report. We will look through those very carefully to assess the recommendations that are made, the perceptions that come out of those work shops. The more specific those recommendations, the clearer the perceptions, the less generality we get, the more help those reports and these work shops will be to us. We expect to sift the series of recommendations that come out of this series of work shops and try to translate those into a program. We will continue to communicate with you over the coming months to tell you where we are and where we are going. We will try to then establish those programs as follow-ons or as new starts or as redirections of programs that are now underway, some of which were touched on today. But, the message really is that the more you can give us your thinking in specific terms -- not in generality, we know what those are already -- the more you can give us your thinking in specific terms, in recommended effort, in perspective output, the more value we will achieve as an industry and the more value you will achieve for your efforts here, and that's the way I hope you will direct your work shop activities tomorrow.

If you have not signed up for a work shop, you can still do so. The sign-up sheets are out by the registration desk. If you fail to do so, you get one demerit, but you can get into whatever work shop you want tomorrow when you get there.

We announced earlier that there will be a reception at about 5:30, from 5:30 to 6:30. That reception will be in the poolside terrace room on the third floor. The gambling facilities you can find yourself.

Thank you very much for your participation today and thank you for your comments.

(Whereupon the workshop was adjourned.)

SESSION III

(May 15, 1981)

MR. YULO: Good morning, ladies and gentlemen.

I don't know what took place last night but somehow this hotel, effective today, will be called the Sands.

Today's proceeding is being recorded and also we have a Court Reporter.

Various workshops have prepared documentation and it will be available, outside of the auditorium door.

After the remarks by the Chairman of this session, we would like to have the workshop moderators come up and sit up front here so they can be available to answer questions after they make their presentation.

Now, with great pleasure, I would like to introduce Jack Harrison, Director of the Office of Aviation Safety.

MR. HARRISON: Thank you.

Well, I attended a number of interesting sessions yesterday and it appears that we are moving right along with our objective to solve the human problems in aviation.

This is the fourth session that we have had.

The first last November at TSC in Boston was one in which we had panels representing the Government, the airline pilots, commercial aircraft manufacturers, and commercial airlines.

The second was in conjunction with our commuter safety symposium held in January where we addressed the human factor issues in the commuter aircraft design, design philosophy and human factor criteria, which were employed.

In the third we addressed the general aviation helicopter, air traffic controller and aviation metrication.

Here we heard our speakers. We had Joe Del Balzo tell us that if you give us the right problems we'll develop the right program.

Jim Bispo developed the scenario and developed our program and Sieg addressed human problems, but I don't think we're going to have a floor show here today. I don't see any curtain here, Sieg.

Neal gave us an overview and an evaluation of the evolution of aircraft traffic control over twenty-five years and a glimpse into the future.

Bob Orr discussed the rapidly changing system, of the need for flexibility, and the efforts of MITRE and their programs.

Gerry Thompson gave us some impressive numbers concerning the number of facilities and the state of the facilities with respect to obsolete technology.

Ken Hunt, in a brief presentation, covered all the problems with respect to pilots and air traffic control interface.

Bob Orr says he's going to tell air traffic all about it.

Dr. Kinney discussed the development of the SOP program and several others in the MITRE project.

Bill Reynard tells us about the ASRS Aviation Safety Reporting Program, which was a five year effort drawing to a close, this coming September, to develop a safety analysis capability out of the voluntary reporting system.

Bill Young addresses the commonality of aircraft technical programs, in both civil and military, of which emerged the issuance of the level of automation of integration of ground and aircraft control and the allocation of responsibility.

Bob Warner, what I think that I heard from him, was that the issues of pilots or controllers are ego's, on vanity, that get in the way of system understanding.

Gary Church, I think, said, "I don't fix it if it isn't broke, and can we afford it if we don't need it."

Al Kulikowski told us that the controllers of tomorrow may be passive instead of aggressive as he views them today.

Howard Johanssen gave us an impressive perspective in the attitudes of the system specialist work force.

Jon Ross gave us some interesting perspectives in the values that we should use involving issues in programs for human factors.

I think this gave us all a start on the programs and as I said yesterday, it appeared that all of the groups were working towards a resolution of the problems.

I think we should hear from them now.

So may I ask the group leaders to come up to the table.

(Group leaders comply.)

Mr. Harrison: First we will hear from Ed Barrow, who had the subject "The Controllers Role in the Automated Environment."

Ed, as you heard on Wednesday, is a former Deputy Regional Director of the FAA and at the present time he's an Air Traffic Systems Consultant for UNIVAC Corporation. Ed.

MR. BARROW: Thank you, Jack.

We were asked in our initial briefing, as moderators of the work groups, to pinpoint and bring out the human factor problems and to submit specific recommendations for the resolution of these problems.

To start with I would point out that I found that to be a human factors problem in itself.

We were given a briefing a couple of days ago on the work that is being done on the development of the automated system and, there is much work that is being done as you all know, and there are many people involved in it. Then the following day we were given five hours to develop innovative ideas and points which should be considered in the development of the system.

Now, either somebody is awfully naive to think we can do that, which in itself is a human factors problem, or, if the other groups were able to do it and we weren't, someone made a damn poor selection in the moderator for our group. Either way, we have a problem.

I would like to start out with a few personal remarks. It seems very popular today to criticize the FAA and the present air traffic system. You read it

in the newspapers. You hear it on TV. It's done both outside the Agency and by people within the Agency. Everybody tells us what a poor air traffic system we have.

I just don't happen to think its that poor. I happen to think it's probably still the best in the world. Certainly there are a lot of shortcomings. Certainly it needs to be improved and, certainly it needs to be automated, but we should profit in the development of the new system and in planning for the new system from the mistakes we made in the past.

I have heard comments in the last few days about the shortcomings in the present system and that whoever designed the system certainly had never heard of the human factors element and that, in its development, the controller hadn't had the proper input and the human factors people weren't consulted. I think these points are valid.

Probably the most illuminating thing I've heard here has been Neil Blake's remarks on how they are proceeding in developing the replacement system. They are going to do it on an evolutionary basis. They are getting controllers input, the technician's input and the input of the various disciplines. In other words, I think they're really on the right track as they proceed to come up with the system which will eventually assume the responsibilities and replace the work that is being done by our present system.

Now, when we got into our particular workshop discussions, as Jack mentioned, we discussed the controller's role in the automated environment. You can't really get into what that role is going to be in the future automated environment without first considering what the controller's responsibilities are now and how the present system operates because we have a transition period that we have to go through.

It's not going to be a situation where next year, or the year after next, somebody is going to pull the plug and say the old system is gone and here we have a new one. It's going to be done as Neil Blake's concept points out on a very definite step-by-step program. I think It's good that everyone seems to be thinking along these lines.

In the present system the controller is the spark plug of the system. The ATC System as you all know, has three major elements: the equipment, the procedures, and the human element. When I mention equipment, I am talking about

the airborne equipment requirements as well as the equipment used by the controller, and the rules and procedures that are used by both the pilots and controllers. The human element includes both the pilot and the controller. Those are the three basic elements that we have.

Those same three basic elements are going to have to be contained in any replacement system.

Today, in the present system, the controller's role is pretty much as I mentioned, as the spark plug and, as a backup when part or parts of the system fails - the man who steps in and takes over.

He is the one that determines what procedure and what equipment will be used in a specific situation. The equipment is merely a tool to him - he makes the decisions.

Now, as we discussed in our work group, in the future automation system, if the controller is still going to be the man who calls all the shots, if he's still going to be required to step in and serve as the backup when portions of the system fails, you are, in effect, limiting the capacity of the automated system of the future to what he can reasonably step in and handle.

I don't think, and this was brought out in the discussions in our group, that you will ever be able to justify the large costs required for an automated system unless you can show you are increasing controller productivity, increasing the system capacity and capability, and obtaining increased safety by eliminating, or minimizing, I should say, failures due to hardware, software, or human errors. At least, these should be our objectives.

In our work group, I might add, we didn't have an opportunity to fully discuss the remarks that I'm making here, however, it is my assumption from our discussions that we did have general agreement. There were some areas where we could not agree, but as brought out in our first session, we don't necessarily have to agree. It can still be of assistance to the system planners to know that there are areas where there is sufficient controversy to justify further study.

So, in recognizing that the main objectives of the computer replacement program is to increase productivity and provide additional assistance to the controller, as the automation process is expanded and new equipment comes into being, studies will be required to determine what functions and what control

responsibilities and decision making can be taken from the controller and transferred to the automation function. The controller would then become more of a system manager than a system backup or sole decision maker.

We were not able in our group to reach complete agreement on this. We just didn't have time and we didn't have enough information available to be specific on this point. We concluded that there had to be more study and research before the controller's role and duty and responsibilities could be clearly defined in the new automated environment. Certainly, a lot more study than we had time to do in five hours.

Action to define and transfer certain controller responsibilities and decision making to the automated system must be accomplished in an evolutionary manner, as I mentioned earlier.

We discussed at considerable length the need for simulation as a way of finding solutions to some of these problems. The Technical Center here has been a big help to the existing ATC system in checking out new ATC concepts, procedures, equipment configurations, and staffing requirements by means of simulation. I think additional emphasis needs to be placed on this method. I personally don't think, as was discussed at considerable length yesterday in our session, that the controllers alone have the capability of developing and defining what is needed in a fully automated system. By the same token, I don't think the Engineering people can either. I don't think the Human Factors people can either. The important thing is to establish a system and a procedure for getting all of these people aboard and working together as a team.

I believe one of the speakers on the first day said that it is important to know when to bring them aboard. If you bring them aboard too soon, you waste time. By the same token, Bob Orr mentioned in the earlier session, controllers will sit down and tell you what the shortcomiings are in the present system but that is too late. It's important to get them aboard and get their input and acceptance during the development of the new system. Once this is done, instead of being critical, I think you will find the controllers will be in there trying to come up with suggestions and solutions to problems as they arise. This is one of the things I believe we were all in agreement with in our session yesterday.

We also considered it essential that, as the transfer of control functions and responsibilities from the controller to the automated system is effected, there must be a clear delineation of controller responsibility, and conversely, the limits of his responsibility must be clearly defined. I think this is extremely important not only from the controller's standpoint but from the legal implications that are involved as well. This is especially important during periods of partial system failure when fail-safe techniques requiring some controller intervention becomes necessary.

It is very important that sufficient redundancy be provided in the automated system to eliminate or greatly reduce the number of system outages requiring controller intervention. Studies should also be conducted through simulation or whatever other techniques might be useful to define the responsibilities of the controller during fail-safe situations, and what he will need to carry out his responsibilities in these circumstances. We discussed the situation where a controller can handle ten airplanes with automation. If he is going to be responsible for stepping in and taking over when something in the system goes out; can he still handle ten?

This led us to discuss display requirements and what information the controller would have in the automated system, and again, we were not able to get specific because the controller's needs depends purely on what his defined responsibilities are. This is an area that requires further evaluation. When it is determined which control functions can be assumed by the automated system and which will remain with the controller, it can then be determined what information he needs, how should it be presented to him, what data does he need on a full time basis, what is needed on a callup basis, what are the best way from a human factors standpoint of getting the information so it can be presented in a usable form.

We also discussed manpower and staffing requirements including skill retention and training. I think one of the goals of the automation system has to be the reduction in manpower. We keep adding people everytime we get something new; how can we reduce staffing? One of the things that must be considered as we get more into automation is that additional ATC Programmers will be required which may negate some of manpower savings anticipated from reduced controller staffing. As we discussed, one possible answer to this situation would be more dependence and reliance on centralized rather than facility programming.

Some of the controller representatives made the point that if the role of the controller becomes more of a system manager, or overall program planner type, a lot of the fun will be taken out of the job. He may feel that his role is being diminished and becoming of decreasing importance. He is being relegated to a secondary role. He becomes bored. He isn't as attentive, and this, in itself, can result in a reduction in safety. I think this is an important factor to keep in mind.

There is going to have to be a greater emphasis on the use of simulation techniques to maintain controller skill retention by simulating various control situations they may encounter.

Another factor brought up by two or three people in our group, was that, as we introduce more automation into the system, care must be taken that we don't start losing a lot of flexibility that we need to retain. We may become so rigid and regimented that it will be unacceptable to the users of the system. I think this is a valid point. On the other hand, as we also discussed, with careful development of automation techniques in which the controller is given more options, more information, it may be possible to increase the flexibility in the system. Again, these are some of the things that can be further developed and explored through the simulation program and some of the actions that are already underway.

As you can see, we didn't get into a lot of specifics, and for that I'll apologize. By the same token, in the brief time we were together, we were brought up to date on some of the actions that are underway and we can certainly give you our endorsement in the way you are going about developing the future system through a team effort and by getting the proper people together. The key to success is going to be how well this is carried out.

Thank you.

MR. HARRISON: Thank you, Ed.

There is no need for apologies. I think you're going to see a thread of continuity in the reports. The same kinds of problems, the same frustrations. I'm sure the same insight that's going to prove valuable to this program.

The next topic is "The Technician in Automation". The fact of increased automation in air traffic control systems in roles, responsibilities, skills and training requirements of technicians.

Colonel Charles D. Combs of the U.S. Air Force Communications Command assigned to the Headquarters of the FAA.

Colonel Combs.

COLONEL COMBS: Do you mind if I use the mike?

MR. HARRISON: Not at all.

COLONEL COMBS: Ladies and gentlemen, I am most honored to present a report of the Technician Automation Work Group to you and the distinguished participants of the Human Factors Workshop on Aviation.

I would indeed be remiss at this general session if I did not commend our colleagues of the FAA for their foresight in recognizing the acute need for continued collective participation on such important safety related subjects. On behalf of the United States Air Force, I acknowledge that contribution of those individuals within the FAA that arranged this forum.

At the same time, I share the dedicated interest, the determination and support provided by other government and industry organizations that brought forth the personal professional talents represented in this joint aviation effort. It is indeed paramount to identify, to understand and to compensate for those mental and physical frailities categorically identified as human factors. They are not unique

However, the lack of an equalizing offset in aviation can assure catastrophic consequences. A pilot receiver, a wrong altitude assignment - and the controller fails to check and correct the error - or the maintenance system technician enters a wrong voltage setting and - the result we reap could well be a catacylsmic loss of life, property and equipment.

When we speak of human factors, we, of course, recognize it is not only human failure itself that we must isolate and analyze. We must identify and remedy the cause. The initiated fault may stem from many variables. Poor management practice, conservation, and family oriented pressures, are only a few of the many sources that are not exempt, and often hold equal importance with direct job related influences. It is with this awareness that our technician in automation work group prepared this report.

At the outset, I should clarify that the report does not postulate a singular orientation with an automated environment. While it is accommodating to a

changing environment precipitated by the increasing use of automation to meet future evolutionary innovations, it is also acclimated to the necessity to grapple with the present cycle considerations. From a variety of human factors, the thrust of our report is people oriented with the acknowledgement that people are our most important asset.

At this point, it is perhaps fitting that I offer a degree of humility and embarrassment. It is with regret that we could not accomplish to our satisfaction in five hours what could not be reasonably achieved within a full work week. In light of this human frailty, you will note that our report is in outline form to highlight general areas of concern. Some specific recommendations are included. As moderator, I assumed the liability of inviting participants of our group to provide their later thoughts and recommendations as a follow-up to our one day session. This is to provide the FAA the benefit of specifics to insure better understanding of the concerns highlighted by the work group. Any furhter input that I might receive will, of course, be forwarded to Sig Poritzky for his dissemination to the appropriate FAA offices.

Now, to turn to the documented portion of our report. We have categorized ten general areas of concern, which will first list and then address in more definitive terms.

These are, environmental issues, training, system design, management, certification of equipment, maintenance philosophy, technical documentation, logistics, budget limitations, and national trend and design problems.

To take a look at the environmental aspect, we did not fail to consider such things as the need for restroom facilities and even showers at some locations, particularly in isolated and remote areas. For example, the maintenance technician who works with equipment that contains emergency battery acid or other caustics may well have a need for a shower at the work area.

In looking into other physical hazards and personal safety considerations it was noted that the Department of Defense has for years made special provisions for potential electrical shock hazards. Specific note was made of the fact that the FAA should review such DOD procedures. The U.S. Navy program called Heftman (H-e-f-t-m-a-n) was specifically referenced for FAA review.

Another point was that consideration should be given to the use of the buddy system, as we call it, in the Air Force. In other words, you don't send

one individual out to work on high voltage electrical equipment unless you have a mate to go along with him in the event that there should be an electrical shock. Again, the DOD has some rather extensive procedures on the subject, and we suggest that the FAA look into those.

Another thought was on communication capability at remote sites. There is a need in some cases for emergency telephone access as a safety measure.

The need for individual storage space in the work area was also mentioned. This would provide the technician a reasonable place to store his own technical data, personal training notes, and etc.

With regard to the training area, we looked at three broad areas of concern. One concerns transition of the work force. This concern highlighted earlier in our opening session by Gerry Thompson. The level of technical competence was another area, and the third was the certification of people. To identify the reasonable span of knowledge requirements, it was recognized that a special study might well be required.

Consideration should also be given to providing adequate time and space for training at facilities. There are some facilities where apparently, there's just not enough time allotted for required training.

The first specific recommendation is to provide sufficient notice in advance of training and review the latest training technology. It was found in some cases that people were sent to the Oklahoma City Academy for training with such short notice that they didn't have sufficient time to prepare for it. In other cases, people were rotated from one training location to another perhaps more than necessary following formalized academy training. At least there should be more human needs consideration given to the selection of the assignment of training locations as well as formal training at the Academy.

The third area is system design, and of course, this is Pandora's Box. In this case we felt the FAA should assure joint controller and technician participation in the preliminary requirements definition as well as review of the specifications and analysis of design. Participation should continue through testing and evaluation, in diagonal slice groups, and throughout the acquisition process to make sure that users needs are met.

System design should also consider the transition from old to new equipment.

Transition of new equipment. We all know that this is certainly a concern that needs resolution. Planning in advance is a must. Another is availability. Here you get into such things as maintaining reliability in design. Another area to look into is flexibility in facility reconfiguration and also the consideration of modularity, using components in equipment so the technician doesn't have to try to solve the problem on site at a given facility.

In other words, the system design should permit the technician to pull a printed circuit board out or pull a component out and send it back to the major work center for repair. It is recognized that this is a fairly well inherent system design nowadays. However, it was thought that there should be further consideration of this option.

Failure in detection and reporting was another item. Also, testing, evaluation and verification need to be looked into with greater depth.

Software support and the need for expandability when we design the system is also paramount.

We have had the same problems that Ed Barrow related here, and we have given you a lot of areas to think about. It's been very difficult in the time allotted to go into specific detail to the point where it might be productive in engineering development continuity to fully comprehend some of the thoughts for system design that came out of our workshop.

Another area is management. Under that grouping we had quality of work life along with several other ideas on some of the things involved in the management arena. Relations between the supervisor and the employee was one. Another area of importance is controller and technician relationship. We need to review some of the things that go on between the controller and technician and try to get them to work together in closer harmony. After all, here we have a triad; the controller, the pilot and the technician.

Labor relations was another topic. It was mentioned that management has to be continually cognizant of those considerations of the administration of current policies and procedures. We should minimize the paper work and the administrative reports process.

Staffing is still another area for review. Current staffing availability with consideration for work pressure on the future work force, and the need for balance between equipment and manpower.

To save time here, we might summarize this to examine the technician's role in context with the need for task changes to maximize incentives for higher responsibility, and to minimize complacency.

Certification of equipment was our next major area. Under this area, we considered the need for a standardized system of certification procedures for all the various kinds of systems that are part of the national air space system.

The next area is maintenance philosophy. It is noted that the FAA has embarked on a new conceptual philosophy for carrying our maintenance responsibilities. One consideration of this philosophy is the transition from a program necessitating frequent on-site visitation to the method of remoting technological data to a central work area. Although it is duly recognized that budgetary constraints, and size of the work force restrictions dictate a conservative approach, system safety and effective management must remain the governing factors. In this context, the FAA should consider the potential adverse impact on services when reducing preventive maintenance.

The next area is technical documentation.

Here, mention was made of trouble-shooting aids and maintenance test equipment. Specifically, the FAA should develop a program that will insure the current accuracy in all required technical program documentation, manuals and other trouble-shooting aids. In addition the agency should provide a standardized test equipment program for all present and future facilities.

The thought here is the use of computer aids, trouble-shooting aids should be designed to complement technical documentation. National Cash Register, Caterpillar, and Air Force job performance aids should be reviewed in establishing guidelines for technical manual documentation and training requirements. It was felt benefit could be derived from taking advantage of programs already established by other government and industry activities.

The next item is logistics. Here when I say logistics, I am talking about requisitioning through the direct supply process. The group was most happy in this area. In fact, they thought the FAA should have an acclamation. The FAA implementation of a computer base requisition of parts and inventory system was considered a viable, necessary approach to insure continued system integrity.

The next area is budget limitations. Our group recognized that budget limiations are necessary, but feel that adequate funds must be provided to

prevent shortcuts in human factors and maintenance safety elements.

The tenth area is the need to identify national trend design problems for system specialists, controller, and pilot participation in the continuing evolution of the system.

The following items in this case are felt to be of significance.

Feedback documentation. This is needed in all areas, but specifically, for example, on national change proposals disseminated by the FAA. Configuration control, the technical information system, and of course, software support.

Those, ladies and gentlemen, are the areas of concern.

I was asked before making this formal presentation to ask for provisions for those participants in this group to be able to continue their input because it is felt that human factors play a major role not only in the comfort of an individual, but how well he can do his job. So the FAA should continue this kind of program.

Another request that I had just before making the presentation, was don't leave human engineering to the systems engineer. Human engineering and systems engineering are separate entities that must go together.

Again, it was may pleasure to serve on this group and I would like to thank the members of the group for the hard work they put into this effort.

I regret that we did't have more time to voice some of the specific concerns that were injected.

Thank you.

MR. HARRISON: Thank you, Colonel.

Your suggestion leads me to advise that the entire program was intended to establish a relationship with the users in the system so we can get continuing advice with respect to the problems and the requirements for the solution of those problems. In addition your remarks concern the need for an opportunity to have further submissions in the program later. It was my intent to advise you that we will be holding the record open for probably thirty days, in which event if any of the participants feel they can contribute further by summarizing their assessments or the articulations of requirement in a suggested programs for research, that's the sort of thing we would more than like to have and to include in the proceedings.

The third topic is the "Impact of Transision on the Human; Near and Long Term". The subject is concerned with factors affecting the controllers and technicians during periods of system change.

Dr. Julien M. Christensen, Director of Human Factors of the General Physics Corporation, Dayton, Ohio, was chairman of this working group.

Dr. Christensen.

DR. CHRISTENSEN: Thank you, Jack.

Since I spent from seven to approxiamtely eleven last night making my small contribution to the coffers of the Brighton Casino, and 11:30 to 2:30 watching the Celts beat the Houston Rockets for the championship, I had only from 2:30 a.m. to 5:30 a.m. to do editorial work on the materials of our workshop. I will remain seated if you don't mind.

I want to begin by acknowledging the assistance of an excellent team, fourteen people who joined me, including our Chairman, Jack Harrison. Their names are: Shy Aitken, Transport Canada; Rod Bourne, FAA AAT-110; John Gersch, Sperry Univac; Mitch Grossberg, FAA Tech Center; Jack Harrison, FAA ASF; Howard Jaslow, Gould Simulator Systems Division; Ezra S. Krendel, University of Pennsylvania; A. J. Kulikowski, FAA, Air Traffic; Bob Murray, C.A. Electronics; Chet Lament, FAA AAF; Evan Pickrel, FAA-AAM500; Bob Rinehart, FAA Tech Center; Chuck Semple, Canyon Research; and Gerard Spanier, FAA Tech Center. I am deeply indebted to all of these very active and productive participants who were strong of will and definite of opinion and yet were willing to subvert their individual opinions to what we hope is the good of our little group.

I will present our items in the following format: For each, I will list the issue; next I will define the problem as we see it, and, finally, I will present our initial thoughts on the research direction(s) that might be taken to solve that problem.

The first issue is maintenance during equipment/systems changeover.

Issue: Maintenance during equipment/systems changeover

Problem Definition:

FAA ATC Maintainers face several problems as new systems are introduced and older systems are phased out. For example,

a. New skills and equipment characteristics must be learned, while

b. old equipment characteristics are remembered and old skills are maintained.

c. Learning of new skills must be accomplished concurrently with normal job routines.

d. Negative transfer of training effects may be generated by the changeover.

History has shown that if maintainer skill levels are low, their actions on existing problems can cause new problems in about 1 out of 3 cases.

Research Direction:

1. Examine alternative strategies for effectively and efficiently training new skills while maintaining existing skills.
2. Develop criterion-referenced maintainer training for learning new skills.
3. Examine impact on ATC systems operation of these transition training requirements, and evaluate alternatives, including: CAI, OJT, contract maintenance support during peak transition training.
4. Examine current and projected performance problems throughout the broad band of skill areas required by each maintainer, and develop and evaluate recommendations for overcoming the performance problems.

Similar problem for controllers

Issue: History lessons

Problem Definition:

To attempt to facilitate both near-term and long-term transisions by studying past experiences in transition.

Research Direction:

A wealth of information regarding all aspects of ATC operations exists in the minds of experienced FAA controllers and maintainers. There are human factors engineering methods for systematically and objectively gathering and interpreting that information for use in establishing protocols for near-term and long-term transitions.

Clues and initial hypotheses can be derived from workshops such as these but they must be followed by systematic inquiry, using the techniques referred to above.

Issue: Systems criteria sensitive to human factors engineering parameters

Problem Definition:

Evaluation of alternative designs, training programs, procedures, etc. depends on availability of criteria that are reliable, valid and sensitive to changes in human factors engineering parameters.

It may be necessary to develop criteria specific to each sub-area, such as navigation, enroute ATC, terminal ATC, communications, etc.

Research Direction:

Available criteria (e.g., performance inadequacies, workload, errors, etc.) should be examined with respect to their adequacy. If found to be inadequate, a program should be instituted for the development of criteria that will enable conclusions to be drawn regarding the relative effectiveness of alternative designs, alternative training methods, and so on.

Issue: Controller-Directed Training Programs

Problem Definition:

There currently exist different "generations" (a continuum, not discrete) of air traffic controllers. Each "generation" was trained differently for the systems that were then current. Each "generation" has its own biases and operating approaches. Therefore, there cannot be a "universal" training program. The training programs must be generation-specific.

Research Direction:

1. Define generations with respect to ATC systems, attitudinal influences, etc.

2. Define generation-specific training requirements.

3. Define generation-specific training programs.

NOTE: Perhaps should expand this inquiry to include differences within generations as well as differences between generations.

Issue: Counteracting possible inimical effects of change

Problem Definition:

The implementation of new hardware and software systems must be performed with a minimum impact on operations. This includes the construction and installation of new facilities, adaptation to new software systems and new man-machine interfaces, and the actual moment of change-over for each sub-system.

Research Direction:

1. Study and recommend how personnel can be isolated and protected from the distraction and inconvenience caused by the installation of new equipment.

2. Study and recommend those man-machine interface features of current systems that should be continued in the future systems in order to maintain familiarity with systems.

3. Study and recommend optimum timing and grouping of implementation of various programs in order to minimize number of disruptions and their effects.

4. Investigate those features which can be built into the design of new systems which facilitate the switch-over from old systems to new systems and which would allow return to the old system in case of problems.

Issue: Optimization of pilot-controller relationships during transition

Problem Definition:

Both near- and long-term transitions will alter current relationships between controllers and pilots.

Research Direction:

Assessment techniques must be developed to assure that the vital controller-pilot interactions are enhanced, and not degraded, during both near-term and long-term transitions.

Issue: Memory Aids (memory "joggers")

Problem Definition:

With transition to new equipment and systems, memory joggers, that have evolved as a result of considerable experience, may no longer be available.

Research Direction:

A systematic study of the proper place and nature of memory joggers as an aid to near-term and long-term transitions should be developed.

Issue: User acceptance of change

Problem Definition:

The acceptance of near-term and long-term transitions will depend to no small extent on the attitudes of the people who must operate and maintain the new equipment and systems.

Research Direction:

Procedures should be developed for the systematic gathering of the opinions and attitudes of representative samples of controllers and maintainers with respect to such issues as (a) the desirability of contemplated changes, (b) problems anticipated to be associated with contemplated changes, and (c) suggested methods for effecting change, with minimum disruption of operations and maximum user satisfaction. (The cooperation of union officials in these studies is strongly recommended.)

Issue: Part-Task, Transition-Oriented Trainers

Problem Definition:

Transition to automated air traffic control systems is an evolutionary process. Changes will represent modifications of existing systems. Building completely new trainers for each evolutionary change will be expensive and impractical. Therefore, trainers should be transition-oriented (modular in design) for easy modification or should be directed toward part-task training, or both.

Research Direction:

1. Define system design transition stages to automated ATC units.

2. Define trainer requirements for each stage.

3. Define modular features required at each stage.

4. Define part-task training required at each stage including paper and pencil possibilities.

Issue: Models of controllers and maintainers

Problem Definition:

Means are needed for the assessment of the qualitative and quantitative effects of both near-term and long-term changes in procedures, equipment, etc. on the performance of controllers and maintainers.

Research Direction:

Models should be developed that incorporate those psychological, physiological and physical characteristics of controllers and maintainers that are important for successful performance on the various jobs. Then as changes are introduced, their effect can be reflected in the characteristics of the model. It is felt that this would be a useful tool in the development of improved screening programs, training programs and performance evaluation programs.

Issue: Integration of Human Factors Engineering into the Systems Development Cycle

Problem Definition:

It appears that attempts to introduce human factors considerations early in the systems development cycle have been unsuccessful. This suggests that the methods for such introduction and/or the information that was offered was inadequate. Since other studies have shown that 80-90 percent of the critical decisions in systems development are made by the end of the conceptual phase, it is clear that there is a requirement for the introduction of human factors engineering considerations early in the development cycle. The alternative is to relegate human factors engineering inputs to only those things that can still be changed even after the system is well along the development cycle -- "knobs and dials" human factors engineering.

Research Direction:

A thorough study of the systems development cycle from the Requirements Phase through the Operational Phase should be made with aim of specifying the exact nature of the human factors engineering contributions that should be made at each step. The study must include an examination of the adequacy of the methods that are available for implementing the human factors engineering contributions. Inadequacies in either data or methods would provide powerful evidence for the direction that future research should take.

Include in the requirements for new systems design (hardware and software) all of the requirements for orderly transition.

Issue: Near-term human factors engineering contributions

Problem Definition:

Because human factors engineering has not played a significant role in the definition of systems requirements, it appears that operator and technician roles and duties will be defined almost entirely by the equipment for some time to come.

Research Direction:

Human factors engineering methods should be surveyed for their adequacy with respect to how best to handle this reactivity. Application of the methods should disclose (1) whether or not the hardware should be put in the inventory at all, (2) nature of the contributions that can be made even late in the development cycle, (3) implications for unusual selection and training requirements that may be engendered by acceptance of such hardware.

Conclusion: FAA -- you have an impressive intelligence and incredible experience residing in your controllers, maintainers, et al. Take advantage of it.

Thank you.

MR. HARRISON: The next speaker will review the workshop discussion on Controller/Pilot Issues; the effects of future design changes on the interrelationships between pilots and controllers.

Let me introduce Dr. Eugene Galanter, Professor of Psychology, and Director of the Psychophysics Laboratory at Columbia University in New York.

DR. GALANTER: The comments and remarks of our working group ranged from lively to threatening. I believe that the latter were directed mostly toward the chairman, and therefore reflect the convictions of the participants and the abiding interest in the discussion.

We surveyed a variety of issues from which I have selected several to report to you. This selection is based on my own view of the relative importance of the topics we covered, and of course, do not necessarily reflect the views of the participants. However, my sense of the discussion leads me to believe

that there was, if not final complete agreement, at least a convergence of opinion on the relevant agenda. And that friends is not an inconsiderable advance.

We first recognized the importance of, but then agreed not to pursue various aspects of pilot/controller issues including:

1) Tower operations

2) Military-Civil interactions

3) Flight Service & Wx activities

We agreed that our efforts should concentrate on en route services and terminal arrival and departure control, along with the VFR-IFR mix in VMC, as well as the GA and transport mix in en route and terminal operations.

First let us look ahead at coming technology. The facts of the future are clear. The possibility of on-board electornic microprocessor based display systems will be realized -- first by enhancements of current navigational and weather information: <u>local aircraft information</u>, and then by displays containing local airspace occupancy information: <u>area-wide information</u>. These systems will reflect the current developments that are summarized under the rubic of CDTI: cockpit display of traffic information. Such displays we were authoritatively informed are not frozen hardware developments, but rather conceptual notions whose implementations are yet to be realized. The concepts range from pilot-controlled approach and landing spacing, to collision avoidance through display and/or alpha-numeric advisory services (ATARS).

The group raised a series of questions about these new displays and the questions they posed for the relation between the controller and the pilot. The issues raised fell into four major categories:

1) What information is (of necessity) transferred to the pilot by the controller?

2) How is the information to be transmitted (e.g., voice, visual display uplink, alpha-numeric commands, etc.)?

3) Is the information available to the pilot in unencoded form, e.g., controller actuated com radio rechanneling, or altimeter resettings, etc.?

4) What does the pilot do with the information?

So, for example with the available new technologies if controllers rechanneled com radio frequencies by remote control would this improve pilot command effectiveness? Or again, if altimeter setting data was controlled by center controllers would this help unload the pilot of extraneous task requirements? These examples suggest the kinds of issues that must be addressed in the light of developing technology. Currently, the controller looks out for traffic, and maintains flow control at the derandomization points of IFR flights. The work is handled by voice transmission on an open line. The operative input data is a flight plan and a radar (often augmented) display.

We anticipate that with a data uplink technology and discretely addressed transmissions, voice communication may be reserved for information appropriately encoded by verbalization. On the other hand, since much of the traffic control information that must be given to the pilot is geometric or geographic in character, it seems plausible that pictorial transmissions would be of some value in flight path control. At the present time, a revised clearance often requires a search on a paper map in the cockpit for a location coded by five (pronouncable ha!) letters spoken hastily over a busy com channel. Surely worth study would be a plan view pictorial display sent to the relevant aircraft that showed present position and heading (for orientation), and the revised routing, perhaps in a different color. That is to say, we send the pilot a map of what to do. This is not CDTI in the usual sense, but it certainly represents a feasible structure for information transmission. The main point on which there was general agreement was that data should be transmitted in the most appropriate format; and today we should plan for it if fundamental research demonstrates its value.

Such science fiction always raises the question of how to make a transition from the current state to the new and presumably more desirable one. This is a profound problem. In some way we need to develop this technology and its advantages without punishing or degrading the operations of the J-3 driver. This issue is part of the aura of hostility that permeates discussion of pilot/controller interactions ("no transponder huh"). We must recognize that the airspace must accommodate traffic that spans a speed range of an order of magnitude (or more if the military are included), with a useful load capacity range from 200 to more than 200,000 pounds. The freedom of flight must include the

freedom to fly in a variety of forms and for a variety of purposes. Although it was recognized that these kinds of problems exists between transport category and GA pilots it was also noted that controllers too take sides on these issues. But after airing these concerns there appeared to be some agreement that some system deficiencies including supervision might be a root cause of the antipathy that seemed to many to be more pervasive than good sense should permit.

Talk moved from specific problems that may require human factors input, to questions of the importance, or even relevance of human factors knowledge for the solution of such system problems. The central point that emerged from the discussion was that the HF specialist, and the end user perceive the system, and its faults or limitations in different ways. The analogy that all agreed caught the essence of the problem was the user reporting a case of measles to the HF specialist.

"The problem," the user said, "is a rash and a high fever."

The HF person replies, "no, no, its not that, its a virus."

The user, who after all is the one who ails, replies, "You're all wrong; I tell you its a fever and a rash, and unless you fix it you're in deep trouble."

Thereupon the HF specialist applies some cosmetic to the rash and administers asperin for the fever; and justifiably complains that work on a vaccine needs to be done.

"Not with my money," the usual response begins, "and especially since you won't provide a scheduled plan for delivery."

The user is absolutely right in his requirement for a solution, and the HF specialist is equally correct about the principles and problems he or she faces. The difficulties drawn by this example probably overstate the positions. Our group eventually agreed that some form of parallel progress may meet certain issues if a coherent position on the central questions could be developed. Without suggesting a solution the group did propose certain unifying items for team directed efforts.

Some of these points were:

1) Information transmission and display are critical items in the movement of air traffic, and should receive a large share of basic and developmental research effort.

2) Timeliness and appropriate formatting of information for immediate applications are critical items for the development agenda.

3) Demonstrable effectiveness is the final criterion for new technology; and this requires HF measurement methods based on psychological research data of more powerful kinds than we have used in the past.

The interaction of pilots and controllers was also noted to be a human connection. That is, issues of a social nature become relevant to system design. Controllers need better methods than informal "voice stress analysis" to assess pilot competence and familiarity with local procedures. On the one hand such judgments may enhance system flow, but equally likely from an apriori position is that these judgments may be as often wrong as right. We do not even have a name for the kind of "discourse analysis" that should be investigated to examine these questions. But just as the controller evaluates whether the pilot can hack a rerouting, the pilot listens to that voice and wonders whether the controller knows where the tall buildings are before giving a new vector, or whether after not being turned over to approach at the seven mile gate, the pilot hears in the controllers voice the sound of surprise that the pilot is still on the center frequency. All of this discussion was just that -- hanger talk -- with no real data, or even justified opinion for support. But the discussion was pursuasive. We need to look into such "soft" issues, at least to determine that they are purely epiphenomenal.

At this point, the chairman exercised his prerogative to present evolutionary directions for system development. The central notion is that pilots and controllers are both constrained by geography. Whereas this is a necessary condition for the pilot, it is only a system design decision based on the limited technology of the late thirties. Today, there is no reason to continue this constraint if when jettisoned it improved system performance. Controllers today perform a variety of distinct functions for a limited geographical area. Therefore every controller has to have the temperment and be an expert in flight planning, communication, surveillance, and conflict resolution, to name just a few of the controller functions. With current and expected computer enhanced technology for tracking and alphanumeric display the potential for dividing these functions is at hand. Instead of three controllers doing the same complex of jobs for three small areas of air traffic; each could do one kind of job for larger airspaces. So we can envision a surveillance controller toggling poten-

tial conflict based on a planners re-routing. The conflict resolution screen lights up for our resolver, who may test three vectors for long range consequences, and then transmit the suggested resolution to the primary communications controller as a combined alpha-schematic display. The com controller may choose voice com to the pilot, data uplink to a CDTI, or alpha-message to the cockpit alpha screen.

Notice that controllers retain operative functions in the system as decision makers and planners, rather than calculators and estimators. The computers do the calculating and probability estimates, the controllers evaluate and decide. These are the two fundamentally human roles that simply are not adequately handled by computation. But even in the role of calculators, the final discussion centered on what we all have experienced -- system faults.

We all recognized the intrinsic reliability of modern electronic systems, and their error detection and correction capabilities. But we all worried about the sort of failure that does occur -- all the lights go out. How to backup, ha there's the rub. But also a more insideous and less obvious kind of fault has been growing in new systems. These are the software logical glitches. In systems of the complexity necessary for air traffic control, analysis of program structure is not enough, and program exercises may not always catch the bug. We must accept software glitches, and be prepared to exercise human judgment to defend against catestrophic failure. But this is what we do today, and we're not doing a bad job.

MR. HARRISON: Thank you, Dr. Galanter.

The last topic is "Controller Performance As Affected By the Environment."

We'll hear from Dr. McIlvaine Parsons, Manager of Human Factors Projects, Human Resources Research Organization of Alexandria, Virginia.

MR. PARSONS: I think we have run out of time. Do you have any guidance?

MR. HARRISON: I think you should take the time you need.

MR. PARSONS: Okay, thank you. That means I can stay till at least noon.

MR. HARRISON: Say 11:20, maximum.

MR. PARSONS: Our group was fortunate in having some very articulate participants, including representatives from Mexico and Canada and participants

who, by and large, answered the technical questions that were embraced by the topics assigned. There was a little bit, as there always is in workshops, of therapy for some of the individuals participating and that's one purpose perhaps, of a workshop.

We came up with eighteen research or study needs. (asterisked in the margin of this report). This may seem a surprise to some of the participants but reflects the acute capabilities of interpretation on the part of the Chair.

IMPACT OF NON-TASK-SPECIFIC WORK ENVIRONMENTS

The first topic dealt with the impact of non-task-specific work environments. We defined these environments in two ways. One was particular settings. There were four of these. The en route centers, the terminal centers, tower cabs, and flight service stations. Characterizations consisted of transient conditions and overall layouts of work and locations. Ambient conditions included temperature, noise, and lighting.

Ambient Conditions

It became apparent with respect to temperature that there were some difficult situations in some locations. There were a few horror stories about having to wear mittens at work as well as a sweater and jackets and things, and having to take off one's shirt because it got too hot. Apparently, there are variations of temperatures in different parts of some control locations that add to the problem because it is very difficult to make adjustments for the entire location.

The effects of nonextreme temperature and of discomfort in temperature could include distractions. But this is a difficult topic to sort out. If effects did include distraction, that could affect performance. Presumably it wouldn't affect people by inducing them to go away, as temperature discomfort often does elsewhere. There seems to have been no systematic survey of temperature conditions at various work locations.

With respect to noise, there were two types of noise that were singled out as being somewhat distressing. One was, as I recall, high frequency (high-voltage) noise to which hearing is sensitive, particularly among younger people. Older people, like older managers, are not as sensitive to high-frequency noise and they may not understand what's going on where the younger controllers might

be more distressed. The other type of noise is conversations, particularly by visitors. These can be another source of distraction and are uncalled for.

Apparently, there has been a fairly recent Tech Center study and quite a few recommendations with respect to lighting, but these have not been fully implemented partly due to the decentralization and autonomy that characterize various centers and working locations. Probably the lighting problems are not extreme, so they did not create any critical situation. You do get, once in a while, a critical item, such as a tower cab at Des Monies which was beautifully constructed but located with the airport beacon right outside of it, so, a different kind of illumination was introduced into the tower cab.

Layouts

Problems in overall layout seems to characterize the tower cab and flight service stations more than centers.

The flight service station modernization program was said not to have included any analyses of the tasks of people working those stations that could guide the design of the layout of equipment. Therefore, task analysis/description seems badly needed.

It was noted that Transport Canada has a new design in the tower cab that I think merits some attention from the FAA, which could write and get information about it.

The aisle arrangements for pedestriation traffic through centers were discussed with regard to distractions. There has been at least one major FAA study on configurations of consoles and their effects on communication. The present in-line configuration seems to be pretty well frozen.

Elements in Physical Work Space Affecting Performance

The second topic consisted of the elements of physical work space affecting performance. These fell out into displays, seating, input devices, flight strips, weather information and sector suite design. I will try to go through them quickly.

DISPLAYS

With regard to displays, there was considerable discussion pertaining to horizontal versus vertical display. Now, you may note that I, like Dr. Christensen was, am hunched over examining a horizontal display (my notes) to

get my eyes close to it, and this position seems to be characteristic of what happens in work locations in FAA Centers or particularly in towers, where, as I understand it, the display is horizontal. When I hunch over like this, I'm in a very tiring position, particularly through a long period of time. Also, it tends to require a different type of seating. In Germany, on the other hand, there are vertical, brightly-lit displays and one wonders how and why their design differs from those in the United States. Some FAA investigation seems warranted.

Headaches can come from the displays themselves, as research on visual display units has brought out with respect to the new types of office word processing equipment - the VDU's with their CRTs. Glare is a major factor. It would be useful for the FAA to consider a study of glare effects of each display unit in case these create headaches among controllers.

Seating

But it is the seating that causes the headaches that apparently have been reported, due to the posture of the individual; headaches can result because the chair presently is not designed for a horizontal display but for a vertical display. In general there are problems in anthropometry with respect to seating, and an adjustable seat seems to be advisable.

Input Devices

With regard to input devices, there was some discussion about the respective merits of the ABC versus the Querty types and the rationales for the ABC keyboard. Error rates with ABC input devices have ranged from 20 to 30 percent in some of the MITRE studies. Some problems have arisen from trying to make inputs with the keyboards and trying to watch the scope to maintain aircraft separation at the same time.

An alternative to keyboards could be touch panels. Here something that might merit study would be redesign of large matrices so that instead of having a solid matrix of 96 by 80, one would break the matrix up into various kinds of groupings, not just functional groups, so that not only reading and visual search but also manual location and manipulation would be easier. Density of information on ETABS displays should also be studied.

On the other hand, it is conceivable that voice input and/or menu selection techniques will make keyboards and possibly even touch panels less and less significant in the future.

Flight Strips

Quite a bit of discussion was accorded flight strips, though I won't go into detail. There seem to be many variations in the use of flight strips presently in different locations,with some local changes in design, as at National Airport. Questions were raised whether ETABS display would really be an improvement over flight strips -- what would be lost and what would be gained? That seemed to be worth a study.

Weather Information

Weather information was discussed at great length, partly with regard to who has the responsibility for its distribution -- for example -- how much the controller was responsible for it. Another question was how weather should be displayed, in view of the proliferations of displays. It was suggested that better display was achievable through broad band display. Problems may arise from scale differences and re-orientations between maps. Use of color was slso discussed. This area seems to merit very careful scrutiny indeed.

Weather information from pilots raises questions as to how controllers would store such information and whether a time reference wouldn't be needed so that the information wouldn't go stale; actually, some aircraft lack weather radars. The conclusion was that current towers and centers don't use weather information effectively and, therefore, further FAA inquiry in this respect seems to be highly merited.

Sector Suite Design

In regard to sector suite design of an advanced nature, the FAA program apparently has done some work with mockups. The question remains, what does the controller really need?

In the discussion at first it seemed as though in the past, description and analysis have been conducted of the controller's task on which to base console design and the sector suite design. In the development of other systems such as military systems, as many of us know, there is an insistence on task description and task analysis as part of the total system development process following function allocation, which in turn follows the original analysis of objectives and requirements. This process doesn't seem surprising to some of us. However, in fact this approach wasn't being used in the FAA though it has been so in the Army, Air Force and Navy. Task analyses were

conducted for the FAA by a firm in 1975 but, apparently, they haven't been used and most people don't know they exist. It did seem worthwhile to study the task analyses and exploit them.

It also seemed advisable, using the task analyses, to examine and compare different consoles as, for example, introduction to ETAB displays in place of flight strips. A recommendation is to have a small FAA simulation facility where one can make such comparisons. Something like this goes on in Canada with a training simulator. It's not an unusual kind of thing to do, in simulation, to compare two different kinds of systems, the current system and some innovation. It has been going on to my knowledge, since my own work in 1954. The problem is how to get baseline data which is reliable and data which will represent the actual environment, in which there is such a great variation.

WORK LOAD, DUTY HOURS, DUTY CYCLES, AND PERFORMANCE

Now we come to the topic of work load, duty hours, duty cycles and performance.

Duty Cycles

In some discussion of work cycles, it seemed necessary to take into account dual differences in their effects. It was concluded with regard to shifts that rotating shifts aren't very good. FAA should reconsider its shift schedule.

Work Load

Although a great deal of attention has been given to understanding work loads, we didn't pay much attention to high work loads or overloads but mostly considered underloads and performance decrements that result from these. One phenomenon was described as "coasting" after a flurry, or "gearing down." Some people still can monitor effectively while coasting and others don't. There are those who can handle multiple inputs in a high-load situation and others who slough off. With a light load, controllers tend to do things they otherwise wouldn't do. What seems to be called for is some kind of behavioral study showing what these non-task behaviors are.

BOREDOM AND COMPLACENCY

Low activity and little traffic do result in what we call boredom and

complacency. These, of course, are intervening variables that are unobservable in themselves. They can be defined by observations of the behavior that indicates them, such as level of activity and by their antecedents and consequences. They seem to be sufficiently significant that they should be investigated, although boredom is difficult to define and to distinguish from fatigue, even by chemical measures. It has been dropped, as we were told, from the FAA's professionalization program, but "complacency" has been retained in that program in an attempt to counteract it. It does seem that in terms of activity, complacency is inactivity, and the consequences consist of not doing something, that is, in errors of omission. Complacency can also be called, more obscurely, perhaps, the absence of professional skepticism, which means assuming that someone else will do something that needs to be done. The high-load counterpart of complacency is preoccupation; they are very distinguishable.

Now, what happens in automation? Automation may impact on complacency and boredom to make them worse. It very definitely seems to warrant an FAA study, which would include an examination of the complacency syndrome oriented towards future development with links to automation. The study should include the antecedents and consequences of complacency. If such variables were carefully examined and operationalized, one could experiment on them and then we might see antidotes to them.

The antidotes that were discussed may have some value. For example, an antidote to boredom exists in off-position activity. You go out and play baseball if the weather is good. For complacency, antidotes are more difficult to imagine. But one of the key concepts that came up was to make sure that there would be feedback in working situations with low load.

This seems to merit considerable study by the FAA based upon the hypothesis that we don't become inattentive simply by not doing something, but rather, because we're not getting any feedback when we're not doing something, we become inattentive. Therefore, to get feedback, you have to do something, and the problem is to get people to do something to get feedback so the feedback will keep them from being inattentive. I believe this notion has not been widely investigated. The FAA may find this a relatively unexplored field of research.

An example was brought out by a participant from Mexico who said that one of their controllers was being rather inactive and complacent and not doing

very much and his supervisor made a point of going over and asking him questions and requiring him to ask questions of the pilot (and this may have happended a number of times) so that this controller would get some feedback.

One solution may be to get some kind of alertness indicator, although that may turn out to be a fairly esoteric matter.

Duty Hours (Duration)

The last item in this topic that we discussed and that seemed to merit study was duration of on position. The FAA has taken some looks at this question recently, with the fifty-minute tests that are repeated. What it should do further is look into other research that has examined, experimentally and otherwise, performance with respect to task duration.

TEAM PERFORMANCE AND PERSONALITY

Finally, we come to team performance and personality.

Difficult Individuals

Obviously, there are difficult individuals who can affect what the team does; some discussion was directed at these and what can be done about them, for example, in the way of therapy, supervisor sensitivity and forebearance, and help in cases of drug and alcohol abuse.

Definitions of Team Performance

We also discussed how one defines team performances and differences in types of teams, such as administrative and operational. The Air Force and the Army are presently doing research in team performance. The FAA might undertake the application of Ed Buckley's individual research to team research.

Team Turbulence

One study that was suggested regarding team performance concerned team turnover -- team turbulence -- trading and rotation in positions and so on. Some could be good and some bad. The FAA should find out how turnover varies in different locations, in towers, in centers, and in flight service center stations, and what effects on interchangeability result from standardized procedures.

Future Systems

For future systems with automation team performance becomes a very inter-

esting topic whether it involves a new member of the team or the computer. The computer should be considered as a team member because that "team member" can be called a friendly computer or an unfriendly computer, for example, in decision aiding. If there is an introduction of automation through computerization, there may ensue changes in organization and in distribution of knowledge and power. Automation can affect the variance amongst team members with respect to their effectiveness; the less effective team members become more effective, so there is an equalizing effect in the team as a result of automation. The FAA should investigate this kind of automation impact on teams.

Information Feedback/Reinforcement

The last team topic discussed was information feedback and reinforcement within a team. A study is needed into how individual team members get what kind of information feedback or reinforcement (or disincentives, too) from other team members and supervisors. There has not been sufficient study of this topic in operational teams.

SUPERVISION AND INDIVIDUAL RESPONSIBILITIES

One of the last two topics was supervision and individual responsibilities. This one brought out a fair amount of therapy in the session, as you can imagine. It dealt with the selection of supervisors, their qualifications, their capabilities, and their self-esteem or lack of it, and the need to give them meaningful roles. Future systems may affect supervision through a capability for recording and analysis of what's been happening. This can include what the supervisor is doing. Nobody seems to know or has a very good idea of what a supervisor does. There seems to be no descriptions of what he does or is supposed to do.

There are some suppositions that he could go away and stay away and nothing would change. This, of course, was the point of view of the controller in the session. Nevertheless, it did seem like a good idea to have a study that would specify not only what the supervisor is supposed to do, but how he should talk to a controller and how he should tell him what to do or not to do. That is a very important skill to acquire. The suggestion was made that generally communication should be improved between employees and supervisors so there is more listening and consulting and trusting on both sides.

SELECTION AND TRAINING

Finally, with respect to the topic of selection and training, we didn't get into these deeply. We did emphasize the need for more work to be done by the FAA in getting better criteria and measurements of the performance of everyone associated with the ATC system, including controllers of various types, such criteria and measurements, of course, to be based on task operations and required knowledge.

We were worried a little bit about the effect of automation, lest this make it easier to measure performance in certain ways and those measures would become predominant and get more emphasis than they should - such as typing proficiency or input proficiency.

There was some concern about the persistence of old training methods because controllers train controllers and these train controllers and they may keep training them in a way that is no longer valid. There was also a good deal of worry about training controllers and skills for backup, whether at the Academy or elsewhere, so they would be able to take over in case there was a need for backup operations.

At this point it was five minutes to five. Somebody suddenly realized that the bus driver was running about three minutes ahead of time, so we broke up in a hell of a hurry before I could thank everyone present for their participation. I'll take this opportunity to do so now.

Thank you.

MR. HARRISON: Thank you, Dr. Parsons.

Thank you Session Chairmen for the obviously extensive effort that you have made to summarize and present the issues and the requirements in this area.

In the future we intend to hold several more human factor workshops. We are going to hold two sessions July 7th, 8th and 9th at the Oklahoma City Aeronautical Center.

One workshop will be directed at environmental and behavioral factors in aviation safety. Topics will include Aviation Medicine, Technology and Physiology related to pilot and controller performance, cabin safety and accident investigation.

Your contact there is Al Deihl, FAA AAM 140 Washington, phone (202) 426-3427.

The second workshop at the Aeronautical Center will be on Aviation Maintenance, and the inter-relationships between design, operation and human factors as they affect safety and continued air worthiness.

This will be the first workshop on this subject. We are soliciting speakers from the industry, so if you, or persons you know, would be interested in presenting a paper on the subject or serving as a panel member, please submit topics to Joseph A. Pontecorvo, FAA NWS 300 in Washington by June 5, 1981. His number is 426-3546.

I would like to take just a minute to tell you what's going to happen with the product of this work. As some of you already know, we will publish a record of the proceedings and when all the sessions are complete, we intend to shred out the issues and the suggested solutions in order to develop a wide human factors program. We will develop a matrix or other format to show the relationship of these issues and solutions to existing programs. We can then decide what is being done and what is not being done and what should be done in order to fill in any holes in the program.

In the process of developing the program, I intend to hold a listening session. Thereafter, the proposed program will be presented to a steering group that will develop the program and attend to the funding of the program needs.

This program is not just an FAA program. It involves inputs of NASA, DOD and the industry.

We hope to find solutions to these human factors problems. We look to continuing cooperation with you and we will probably hold future sessions as the program proceeds and we look to you for your continued participation. We thank you very much for the extensive effort that you have extended to us here in this session.

I would like to again acknowledge the efforts of the workshop chairmen, to extend our thanks to Joe Del Balzo for the use of his magnificent building, to Carlo Yulo who developed the workshop program and arrangements, along with George Long and the members of his staff, and to thank the FAA Headquarters people who participated in developing the agenda, to Michele and her lovely crew in their administrative support, and finally and again most importantly, to all of you.

Thank you.

ATTACHMENTS

PASS
Professional Airways Systems Specialists
Suite 820/444 N. Capitol Street
Washington, D.C. 20001/(202) 347-6065

President
Howard E. Johannssen
Executive Vice President
Mark E. Schneider

January 22, 1982

Colonel Charles Combs
Air Force Communications Service
Liaison Officer
Room 420B
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Colonel Combs:

The Professional Airways Systems Specialists very much appreciated the opportunity of contributing to the activities of "The Technician in Automation" project. Participating in the Human Factors Workshop on Aviation was the first time we, as an organization, had the priviledge to contribute our ideas and concerns involving issues so important to all of us. We believe that the collective participation of all the members in the Human Factors Workshop on Aviation can be a solid foundation for the future success necessary to improve the safety of our National Airspace System. Your role as chairman of "The Technician in Automation" group was an important one and we applaud your efforts in maintaining a fair and expert assessment of the data identified by the committee.

As moderator, you invited all participants of our group to provide our later thoughts and recommendations as a follow-up to our area of concern. Please find enclosed our thoughts and recommendations.

I wish to thank you for your demonstrated concern and dedicated efforts in establishing a thorough report on the topic "The Technician in Automation." Please feel free to call on us for any further work in this area.

Sincerely,

Howard E. Johannssen

Howard E. Johannssen
President

HEJ:ab

Enclosure

"We Will Either Find A Way or Make One"

The report of Colonel Combs, moderator of The Technicians Automation Work Group, categorized 10 general areas of concern. They were:

1. Environmental Issues
2. Training
3. Systems Design
4. Management
5. Certification of Equipment
6. Maintenance Philosophy
7. Technical Documentation
8. Logistics
9. Budget Limitations
10. National Trend and Design Problems

We will comment on each individual area separately.

1. Environmental Issues - It must be understood that the FAA Airways Facilities Division has a responsibility for approximately some 20,000 various facilities throughout its inventory of equipments. Environmental elements at all of these facilities vary greatly with geographical differences, equipment types and designs, and the potential hazardous conditions present in many. The facilities are located in both high density areas and remote locations susceptible to every varied climactic and territorial condition.

The FAA today enforces only limited safety programs where hazards exist. It is imperative that FAA management and employee representatives develop a safety program which will take into consideration environmental and hazardous conditions to provide a high degree of safety in those areas. Human factors engineering is a necessary part of the establishment of any environmental planning program that will apply human factor considerations to both the safety of employees, as well as distribution of work space and human requirements so necessary for proficient performance within work areas.

My recommendation is to study various procedures now used by the Department of Defense and other agencies of the government in developing a safe and realistic environmental program.

2. Training - The training of systems specialists within the Airways Facilities Division is perhaps the most important program within the Agency. The Agency must rely on its training programs to insure technical competence and certified systems specialists to maintain and certify the National Airspace System. The cost of this training program cannot be over-looked. It is reasonable to state that time in training and the cost of necessary courses are approximately $300,000 per systems specialist. This program continues throughout their careers.

In the past, human factor considerations have only been used on a limited basis in developing training programs and employee assignments to such programs. Considering the ever expanding costs versus the ongoing need of training, it is imperative that firm guidelines and initiatives be undertaken to enhance training. We must also develop a reasonable span of knowledge requirements for systems specialists careers within the FAA. As the FAA approaches its capital systems plan of the '80's, we must adhere to human factors considerations and modify all future plans so that human factors engineering will develop the capability of successful completion of any future FAA plans.

My recommendation is to initiate a joint program that will enable open discussion and consideration of human factor designs so that FAA may incorporate these considerations in future training programs.

3. Systems Design - Systems design has been referred to as a Pandora's Box. Unfortunately, we must attempt to develop a review of all systems' specifications and design analysis if we are to increase the ability of the FAA in developing high state-of-the-art technologies and equipments. To achieve this we must assure joint participation between design engineers, systems specialists and air traffic controllers. Through this process, systems specialists and controllers will be able to contribute those everyday common requirements often neglected or misdesigned by engineers not actually working within the day-to-day "hands-on" environment. This participation should be held valid at all stages of design preparation, testing, acquisition and installation processes. This will provide the process by which the users' needs, as well as the maintainers' needs, are met appropriately.

Systems design must also consider transitions from old equipments to new, as well as transition of the workforce required to meet the necessities of old equipments and the challenge of new, complex systems. We must also be cautious in acceptance of new, complex black-box systems without careful testing, as well as functional evaluations. Systems specialists fear not automation, but rather untried systems design without careful monitoring, testing and with design inflexibility discovered only after installation and usage.

We must also consider future detection of systems failures and be cautious in developing design parameters for outage restoration. Careful evaluation must be given to total automation and remote monitoring versus our responsibility in restoration of equipment failures as quickly as possible. Consideration must be given to restoration of facilities and equipments by location and geographic constraints of systems specialists to provide restoration abilities as necessary.

I recommend that a task force comprised of management, engineering, field systems specialists and working controller

personnel become involved in all future systems designs and equipment trends so that the FAA can gain valuable human factors input from all impacted employees segments. This, I feel, will enable the Agency to develop an ongoing process by which all future systems will enable a safer transition and proficient systems in the future.

4. Management - Human factors are certainly an every day consideration. Perhaps the most sensitive areas of human factors are found in the relationship between management and employee. If future plans to automate and redesign our National Airspace System are to succeed, we must address the need for reasonable and joint participatory relationships within the FAA.

The recognition of a triad among management, systems specialists and air traffic controllers must be recognized and accepted. This triad must contribute to the overall success and continued safety within our system. Reasonable levels of staffing must also be balanced with deserving incentive programs. We must understand the varying differences between job difficulty and the presence of stress dependent upon individual requirements, job difficulty and employee attitude. These areas must be dealt with harmoniously by all if we are to accomplish the goals of the future. A need to minimize complacency can be achieved by recognition of the various roles within the triad, as well as the allowance for joint participation within the system.

I recommend that FAA's labor-management relations program be given the ability to establish reasonable and capable decision-making capabilities and share equally in a role that would allow for mutual and free expression to problems without the need for antagonistic policing necessities. Authority must be available for all parties equally to bring about harmony within FAA's management philosophies.

5. Certification of Equipment - The necessary technical requirement to document normal operation of equipment and other requirements of acceptable operating parameters is established within the FAA equipment certification program. The broad scope of facility functions requires a great deal of uniformity, as well as standardization in certification practices and procedures. At present, certification parameters and the presence of inconsistent certification waivers deludes and confuses the program. There must be a standardization of the certification process, as well as an appropriate method of documentation f .: all FAA facilities equipments and Department of Defense joint use facilities.

The National Airspace System relies on various kinds of systems for safety and efficiency. The Agency must recognize and adopt standardization if it is to be totally successful in meeting the intent and responsibility of certification.

I recommend that certification programs be reviewed so that

greater standardization is established and maintained. We must be able to allow some flexibility within recognized safe parameters. This task requires the technical expertise found in the field. Therefore, all segments within the FAA employment ranks should be utilized to develop this goal.

6. Maintenance Philosophy - FAA's past high performance records and safety accomplishments were predicated on a process called preventive routine maintenance. In the future, FAA plans to relinquish accepted standards of achieved safety and approach a philosophy of remote maintenance monitoring and corrective rather than preventive maintenance.

The transition from preventive maintenance to corrective maintenance philosophies is, at best, questionable. The approach must be cautious and based on documented success and proven ability rather than solely total financial savings. It appears by departing from the old preventive philosophy to the new corrective philosophy, our only goal is personnel and cost reduction. It must be understood and clearly evident to all that this transition must not be attempted unless it provides an equal, if not better, safety record for the National Airspace System.

Of prime consideration is the potential for an adverse impact on services when preventive maintenance is reduced. Recognized budgetary constraints and workforce restrictions may dictate a conservative approach, but we cannot accept reckless disregard for the necessities of built-in safety margins that remote maintenance monitoring would destroy.

I recommend that all future programs to reduce staffing and preventive maintenance by installation of remote maintenance monitoring equipment be reviewed in each specific instance. Then, at the appropriate levels, determinations can be made to avoid costly mistakes or disaster. The review must be conducted by all intereted parties who are technically qualified.

7. Technical Documentation - Due to increased reliability of most solid state systems, it must be recognized that instantaneous conceptual knowledge and the ability of systems specialists to respond in such instances may often suffer. Therefore, trouble shooting aids, maintenance test equipment and technical documentation must become an ever more prevalent part of the systems specialists' activities. There must be a firm program to establish a technical programs documentation requirement so that technical manuals and trouble shooting aids are maintained at a current and accurate level.

In addition, efforts to standardize and publish all technical documents in an understandable language form should be initiated. All contracts and designs of new equipments must be supported by accurate technical documentation in concert with delivery and installation of all new systems.

I recommend that all future contracts provide specific language that will deliver readable, specific technical documentation for all systems at the time of delivery prior to full installation and service. Furthermore, private industry has established guidelines for technical manual documentation and training requirements. We should take advantage of established programs in simplifying technical documents so that they aid in the resolution of technical problems.

8. Logistics - Logistics is a problem experienced by all levels of Airways Facilities systems specialists. The requisitioning of required parts and equipments varies from good to terrible. Requisitions for out-of-date parts and non-standardized replacement parts is also a great problem. There are times that systems specialists, as an alternative, will purchase parts locally at their own expense rather than delay restoration by ordering necessary parts through the present logistics system.

I recommend that the logistics system consider a computer-based requisition of parts and inventory system be introduced to all major facilities. In addition, greater scrutiny with specific requirements be placed on contractors and sub-contractors used for the purpose of manufacturing non-standard and out-of-stock replacement necessities. The role of logistics should fall within the realm of specific employees with expertise and knowledge so that they may serve in a supportive role to the systems specialists.

9. Budget Limitations - I recognize the need for fiscal constraint, minimizing of expenditures and adherence to firm budget limitations. I further recognize the requirement for the proper expertise, knowledge and tools required to maintain the safety and integrity of all equipments within the National Airspace System. As real as budgetary limitations are today, so is the reality of the continued safety and integrity of the National Airspace System.

I recommend the following. In preparation of budget processes and legitimate forecast expenditures, every element within the FAA be given the opportunity to contribute methods of savings and/or reductions and budgetary requirements. In addition, these contributions should be expanded to priority listings of absolute necessity, nicety and frivolous requirements of the system. This approaches a realistic attempt in providing solid fact to argue budgetary appropriations before mandatory Congressional reviews.

10. National Trend and Design Problems - The continuing evolution of the National Airspace System will be promulgated with human considerations by management, systems specialists and air traffic controllers alike. We must accurately identify these trends and develop a system by which future design problems can be minimized and, hopefully, resolved before a vast investment of funds. A system by which technical feedback and documentation can incorporate ideas, changes and/or specific recommendations from the pool of talent and resourcefulness of individuals in the various FAA employee

segments is necessary. This program can be initiated by once again convening the Human Factors Workshop on Aviation and provide the technician's workgroup an appropriate amount of time to deal with all facets of this report. Once this is accomplished, we then can provide specific recommendations in each instance.

LIST OF ATTENDEES

Fourth Human Factors Workshop
on Aviation

Mr. Say Aiken
Transport Canada Building
Place De Ville
Ottawa, Ontario
CANADA K1AON8

Senior Master Sargeant Eugene Allen
Air Traffic Control Manager
HQ AFCC/FFC Scott AFB Il
653 E. King Street
Scott AFB, IL 62225

N.D. Allen
Transport Canada
Place De Ville
Tower C
Ottawa, Ontario
CANADA K1AON8

Mr. Ralph A. Amato
Site Leader
MITRE Corporation
FAA Technical Center
Atlantic City Airport, NJ 08405

Mr. James P. Anderson
Director, Office of Air and Marine Systems
DOT/Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Mr. Daniel E. Barrow
Air Traffic Systems Consultant
Univac Corporation
13248 Keystone Drive
Sun City West, AR 85375

Mr. Menashe Ben-David, Chief Engineer
Aero Mechanism
7750 Burnet Avenue
Van Nuys, CA 91405

Dr. C.M. Bertone
Chief, Human Factors Engineering
Sikorsky-Aircraft
130 Peddlers Road
Guilford, CN 06437

Mr. James L. Bispo
Associate Administrator for Air Traffic and Airway Facilities, ATF-1
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Neal A. Blake
Deputy Associate Administrator for Engineering and Development, AED-2
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Rodman D. Bourne
Air Traffic Control Specialist
FAA Air Traffic Service
397 N. Street, SW
Washington, DC 20024

Mr. John Bryant
Assistant Division Chief, ARD-101
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Malcolm Burgess
AFO-200
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Arthur Chantker
Federal Aviation Administration ARD
800 Independence Avenue, SW
Washington, DC 20591

Dr. Julien M. Christensen Director, Human Factors
General Physics Corporation
1010 Woodman Drive, Suite 240
Dayton, OH 45432

Mr. Guinn G. Clark
Marketing Manager ATC Systems
Westinghouse
Box 1897 MS 1682
Baltimore, MD 21203

Captain C. W. Connor
Adj. Professor/Graduate Curriculum Advisor
Delta Air Lines - ERAU Graduate School
9420 SW 102 CT
Miami, FL 33176

Mr. Ralph A. Cooper, Jr.
Air Traffic Control Specialist
ATS, Air Traffic Plans Branch, AAT-110
2590 Treehouse Drive
Woodbridge, VA 22192

Dr. George Couluris
Director, Transportation Systems
Evaluation Department
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025

Mr. Joseph DaCorte
Marketing Manager
Bendix Aerospace
1911 Frt. Meyer Drive
Arlington, VA 22209

Mr. Joseph M. Del Balzo
Director, FAA Technical Center, ACT-1
Atlantic City Airport, NJ 08405

Mr. Donald Dickson
Manager of Advance Programming
System Development Corporation
2500 Colorado Avenue
Santa Monica, CA 90406

Mr. Tony DiVerniero
Chief Pilot
New Air
Tweed New Haven Airport
New Haven, CT 06512

Mr. James Fileccia
Wright Aeronautical Laboratory
Wright-Patterson AFB, OH

Dr. Dan D. Flugham
Senior Staff Scientist
Technology Incorporated
511 West Rhapsody
San Antonio, TX 78216

Mr. Thomas L. Frezell
REsearch Psychologist
US Army Human Engineering Laboratory
504 Wheel Road
Bel Air, MD 21014

Dr. Joseph T. Fucigna
Executive Vice President
Dunlap and Associates Incorporated
1 Parkland Drive
Darien, CN 06820

Mr. Halm S. Gabrieli
MTS
MITRE Corporation
FAA Technical Center
Atlantic City Airport, NJ 08405

Dr. Eugene Galanter
Professor and Director Psychophysics Laboratory
Columbia University
324 Schermerhorn Hall
New York, NY 10027

Mr. Thomas Gardner
Office of Personnel and Training, APT-310
Federal Aviation Administration
800 Independence, Avenue, SW
Washington, DC 20591

Mr. John F. Garren
Langley CDTI Manager
NASA - Langley Research Center
651 Village Green Parkway
Newport News, VA 23602

Mr. John A. Gersch
ATC Systems Staff Engineer
Sperry Univac
1233 Timbershore Lane
Eagan, MN 55213

Mr. Lucky A. Goebel
432 Sheila Boulevard
Prattville, AL 36067

Dr. Charles Graham
Principal Experimental Psychologist
Midwest Research Institute
425 Volker Boulevard
Kansas City, MO 64110

Mr. Charles M. Hall
Display Systems Marketing
Raytheon-Company
Boston Post Road
Sudbury, MA 01776

Mr. Clark Harris
Transport Canada
#9 KHYMER
Nepean, Ontario
CANADA K2H7V2

Mr. John R. Harrison
Office of Director Aviation Safety, ASF-1
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. George C. Hay
Chief, Special Programs Division, ASF-300
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Harry Headley
IBM Federal Systems Division
Gaithersburg, MD

Dr. Lloyd Hitchcock
Systems Simulation and Analysis Division, ACT-200
FAA Technical Center
Atlantic City Airport, NJ 08405

Mr. Kenneth S. Hunt
Director Office of Flight Operations
Federal Aviation Administration
6930 Park Avenue
McLean, VA 22101

Mr. M. Stephen Huntley, Jr.
Engineering Psychologist
Transportation Systems Center
Kendall Square
Cambridge, MA 01503

Mr. Lewis R. Hurst
Staff Airport Engineer
The Port Authority of New York and New Jersey
One World Trade Center - Room 65 East
New York, NY 10048

Mr. Howard Jaslow
Gould Inc., Simulation Systems Division
50 Marcus Drive
Melville, NY 11747

Mr. Howard E. Johannssen, President
Professional Airways Systems Specialists
444 N. Capitol Street, Suite 820
Washington, DC 20001

Mr. Paul Kaster
Staff Analyst
Eagle Technology
2300 S. 9th Street, Suite 400
Arlington, VA 22204

Mr. Edward Kelly
Federal Aviation Administration, AAF-100
800 Independence Avenue, SW
Washington, DC 20591

Dr. Glen C. Kinney
Workshop Chairman
MITRE Corporation
1820 Dolley Madison Boulevard
McLean, VA 22102

Mr. Howard J. Kirshner
Technical Director
MITRE Corporation
1820 Dolley Madison Boulevard
McLean, VA 22102

Mr. E. Kittredge
Sanders Associates, Inc.
Daniel Webster Highway, South
Nashua, NH 03061

Mr. William H. Koch
Assistant Chief, System Design and Integration Division, AEM-301
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Dr. Preston Kohn
Manager
Computer Sciences Corporation
FAA Technical Center
Atlantic City Airport, NJ 08405

Mr. Parneet Kongkeo, President
Aero Mechanism
7750 Burnet Avenue
Van Nuys, CA 91405

Professor Ezra S. Krendel
University of Pennsylvania
211 Cornell Avenue
Swarthmore, PA 19081

Mr. Lloyd Lagrange
National Safety Transportation Board
800 Independence Avenue, SW
Washington, DC 20594

Mr. Chester Lament
Airways Facilities Service
Federal Aviation Administration, AAF-110
800 Independence Avenue, SW
Washington, DC 20594

Mr. Robert Lautenschlager
Group Leader
MITRE Corporation
FAA Technical Center
Atlantic City Airport, NJ 08405

Mr. Jay Lethin
Director of Engineering
Eaton Corporation AIL Division
815 Broadhollow Road
Farmingdale, NY 11735

Mr. Ivan F. Lichty
Manager, Traffic Control Systems
Burroughs Corporation
Paoli, PA 19301

Dr. George Long
Systems Simulation and Analysis Division, ACT-200
FAA Technical Center
Atlantic City Airport, NJ 08405

Mr. James P. Loomis
Manager, Transportation Systems Section
Battelle Columbus Laboratories
505 King Avenue
Columbus, OH 43201

Mr. Steve Lotterer
Legislative Assistant/Air Safety Issue
5th District-Kansas
516 Cannor HOB
Washington, DC 20515

Mr. Walter S. Luffsey
Associate Administrator for Aviation Standards, AVS-1
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. E. Gene Lyman
Consultant
Route 1 Box 256
Keedysville, MD 21756

Mr. Edward J. Malo
Director, ATC Department
Aircraft Owners and Pilots Association
7315 Wisconsin Avenue
Washington, DC 20014

Mr. Edward Mashman
Senior Systems Analyst
System Development Corporation
2500 Colorado Avenue
Santa Monica, CA 90406

Mr. James McDowell
Wright Aeronautical Laboratories
Wright-Patterson AFB, OH

Mr. Don Moor
Lockheed California Company
101 Lockheedway
Palndale, CA 93550

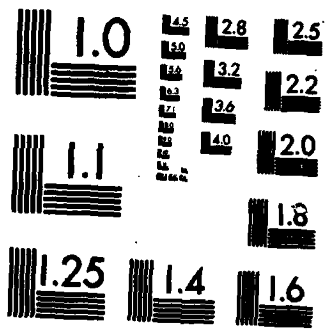
Dr. L. Homer Mouden
Vice President - Technical Affairs
Flight Safety Foundation
5510 Columbia Pike
Arlington, VA 22204

Mr. Harold E. Nord, Jr.
President
Aviation Management Advisors, Inc.
41 South Road
Rye Beach, NH 03871

Mr. Bernard O'Keefe
NJ State Department of Transportation
Trenton, NJ

AD-A150 459 HUMAN FACTORS WORKSHOP ON AVIATION (4TH) TRANSCRIPT 3/3
HELD AT ATLANTIC CITY..(U) FEDERAL AVIATION
ADMINISTRATION WASHINGTON DC OFFICE OF AVIAT.. MAY 82
UNCLASSIFIED FAA-ASF-81-9 DOT-TSC-FAA-81-22 F/G 5/5 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Mr. Robert H. Orr
Executive Officer Air Traffic Service, AAT-10
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. H. McIlvaine Parsons
Manager, Human Factors Project
human Resources Research Organization
300 N. Washington Street
Alexandria, VA 22314

Mr. James Perry
Division Director
Eaton Corporation AIL Division
815 Broadhollow Road
Farmingdale, NY 11735

Mr. S.B. Poritzky
Director, Office of Systems Engineering Management, AEM-1
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. S. Kenneth Puckett
Manager, Advanced Programs for ATC Systems
Amecom Division, Litton Industries
8638 Hayshed Lane
Columbia, MD 21045

Mr. E. Rearick
Sanders Associates, Inc.
Daniel Webster Highway, South
Nashua, NH 03061

Mr. William Reynard
Chief, Aviation Safety Research Office
NASA/AMES Research Center
Moffett Field, CA 94035

Professor Malcolm L. Ritchie
Wright State University
630 Brubaker Drive
Dayton, OH 45429

Ms. Leslie "Jon" Ross
Planning and Procedures Specialist
FAA, Los Angeles ATCT
1 World Way
Los Angeles, CA 90045

Mr. Allan Rossmore
Aircraft Dispatcher
Eastern Airlines Dispatchers - Int. Assoc. of Machinists
12370 SW 22 Lane
Miami, FL 33175

Mr. Clarence Semple
Executive Scientist
Canyon Research Group, Inc.
741 Lakefield Road, Suite B
Westlake Village, CA 91361

Mr. Anthony E. Severino
Chief, Systems Section, ARD-141
FAA Technical Center
Atlantic City Airport, NJ 08405

Dr. William T. Shepherd
Program Scientist
Office of Av. Medicine - AAM 550
Federal Aviation Administration
Washington, DC 20591

Mr. Larry D. Shields
EPDS - (Training Instructor)
FAA Cleveland Tower
Cleveland Hopkins Airport
Cleveland, OH

Mr. Murray Smith
Director, Eastern Region
Federal Aviation Administration
JFK International Airport, Federal Building
Jamaica, NY 11430

Mr. J.C. Snodgrass, Jr.
Director, Aviation Programs
Aerospace Industries Association
1725 DeSales Street, NW
Washington, DC 20036

Mr. W.C. Steber
President
W.C. Steber Associates
717 Noverlook Drive
Alexandria, VA 22305

Mr. Kenneth J. Stein
Avionics Editor
Aviation Week & Space Technology
1221 Avenue of the Americas
New York, NY 10020

Mr. David J. Sweeney
Systems Engineer
MITRE Corporation
FAA Technical Center
Atlantic City Airport, NJ 08405

Dr. Charles J. Theisen, Jr.
Program Manager Air Systems
ESSEX Corporation
65 West Street Road
Warminster, PA 18974

Mr. Gerald Thompson
Director, Airway Facilities Service, AAF-1
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Guice Tinsley
Program Manager, ASF-300
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Dr. Donald Topmiller
Associate Director, Human Factors
General Physics Corporation
1010 Woodman Drive, Suite 240
Dayton, OH 45432

Mr. John D. Vandenberg
Human Factors Supervisor
Lockheed Electronics Co.
US Highway 22
Plainfield, NJ 07601

Major Vendon
653 East King Street
Scott Air Force Base, IL 62225

Mr. Harry A. Verstynen, Jr.
Chief, FAA/Langley E&D Field Office
FAA/Langley Engineering & Development Field Office
M.S. 250 NASA-Langley Research Center
Hampton, VA 23665

Mr. Robert T. Warner
Vice President, ATC, Airports and Airspace
Aircraft Owners and Pilots Association
7315 Wisconsin Avenue
Washington, DC 20515

Mr. Robert Wein
Chief, Systems Engineering Branch, AAF-710
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Daniel Wedo
NJ State Department of Transportation
Trenton, NJ

Congressman Robert Whittaker
5th District Kansas
516 Cannor HOB
Washington, DC 20505

Mr. Richard Wise
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Captain G.L. Witter, JR.
Manager, Flying Operations - Technical
American Airlines Inc.
American Airlines Plaza
Fort Worth, TX 76125

Mr. T.E. Yarbrough
Director Air Traffic Control
Flight Department
American Airlines Plaza
Fort Worth, TX 76125

Mr. Carlo Yulo
Chief, Systems Simulation and Analysis Division, ACT-200
FAA Technical Center
Atlantic City Airport, NJ 08405

Fourth Workshop Attendees
(Additions)

Lyle G. Alverson
24 Village Drive N.
Somers Point, NJ

William Dellner
317 Central Avenue
West Caldwell, NJ 07006

Ken Drew
FAA AAF-100
Airways Facilities Service
800 Independence Ave.
Washington, DC 20591

Mr. Donald E. Francke
Staff Assistant
Air Traffic Control Association
Suite 410, 2020 N. 14th Street
Arlington, VA 22201

Mr. David E. Krohn
Advanced Product Manager
Gould Inc., Simulation Systems Div.
50 Marcus Drive
Melville, NY 11747

Al Kulikowski
2020 N. 14th St.
Arlington, VA

John Park
ARD-340
Airborne Sys. Br.
400 7th St., S.W.
Washington, DC 20590

Dr. Evan W. Pickrel
800 Independence Avenue, S.W.
Washington, DC 20591

Mr. Edward J. Phillips
800 INdependence Ave., S.W.
Washington, DC 20591

Mr. Abe Younger
American Airlines
Ft Worth, TX

Mr. Ed Krupinski
Airline Pilots Association
1625 Mass Ave. NW
Washington, DC

Mr. Gary R. Church
Air Transport Association of America
1709 New York Ave. NW
Washington, DC

Mr. Pete Hwoschinsky
AEM 300
Federal Aviation Administration
800 Independence Ave. SW
Washington, DC

Mr. Leo G. Janssens
ACT 630
FAA Technical Center
Atlantic City, NJ

Dr. Helen Hamilton
FAA Technical Center
Atlantic City, NJ 08405

Steve Devlin
FAA Technical Center
Atlantic City, NJ 08405

Loni Czelkalski
FAA Technical Center
Atlantic City, NJ 08405

Bruce Rosenberg
FAA Technical Center
Atlantic City, NJ 08405

John Riley
FAA Technical Center
Atlantic City, NJ 08405

"MO" Loveland
FAA Technical Center
Atlantic City, NJ 08405

Dr. Mitch Grossberg
FAA Technical Center
Atlantic City, NJ 08405

Robert Rinehart
FAA Technical Center
Atlantic City, NJ 08405

Gerald Spanier
FAA Technical Center
Atlantic City, NJ 08405

John Fabry
FAA Technical Center
Atlantic City, NJ 08405

Dr. Earl Stein
FAA Technical Center
Atlantic City, NJ 08405

Richard Rood
FAA Technical Center
Atlantic City, NJ 08405

Lee Paul
FAA Technical Center
Atlantic City, NJ 08405

Fred Ranger
FAA Technical Center
Atlantic City, NJ 08405

Jack Bing
FAA Technical Center
Atlantic City, NJ 08405

350 Copies

END

FILMED

3-85

DTIC